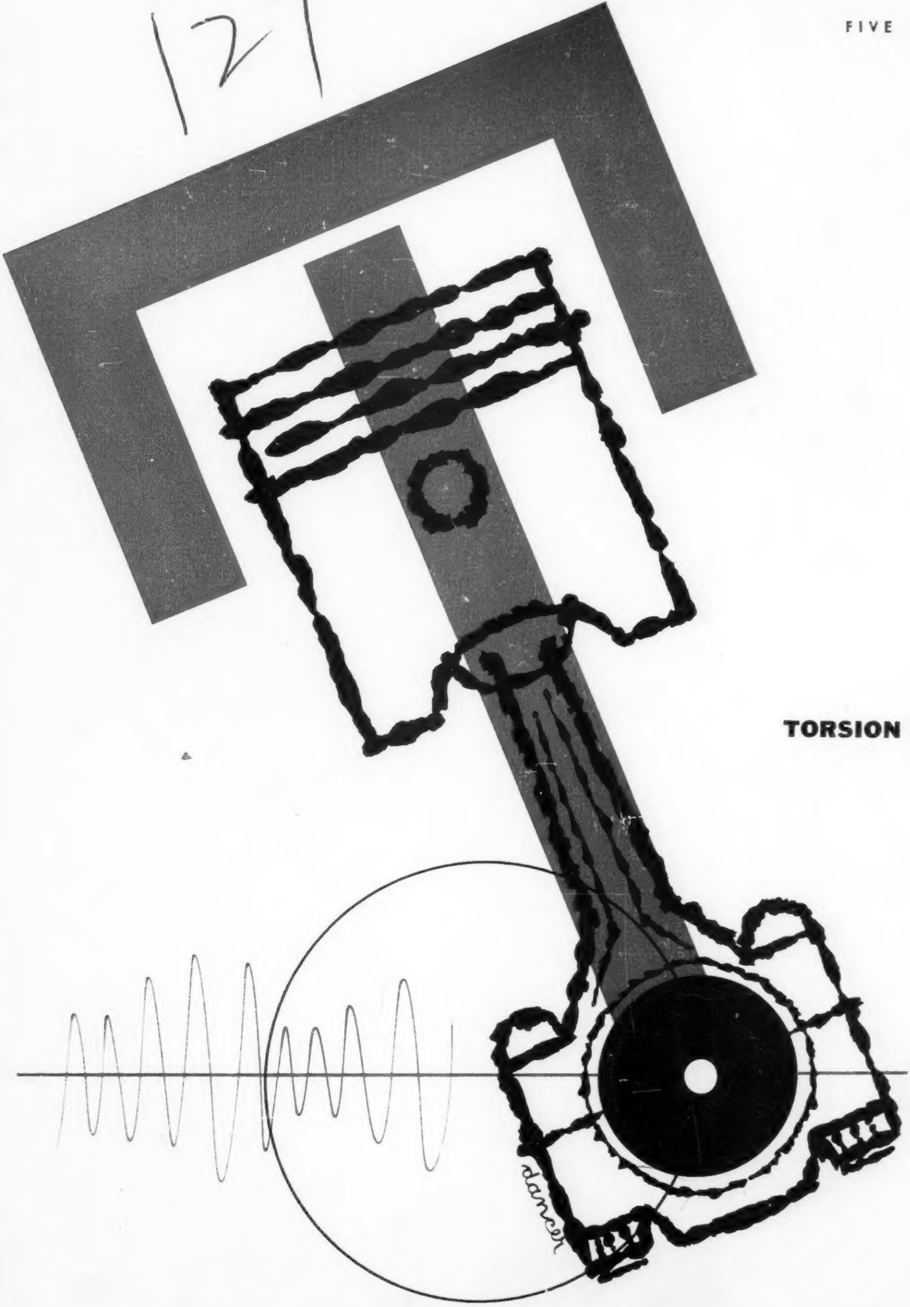
Design Engineering

FIVE DOLLARS A YEAR



$$C = \frac{GI_P}{L}$$

TORSION VIBRATIONS

(Page 23)

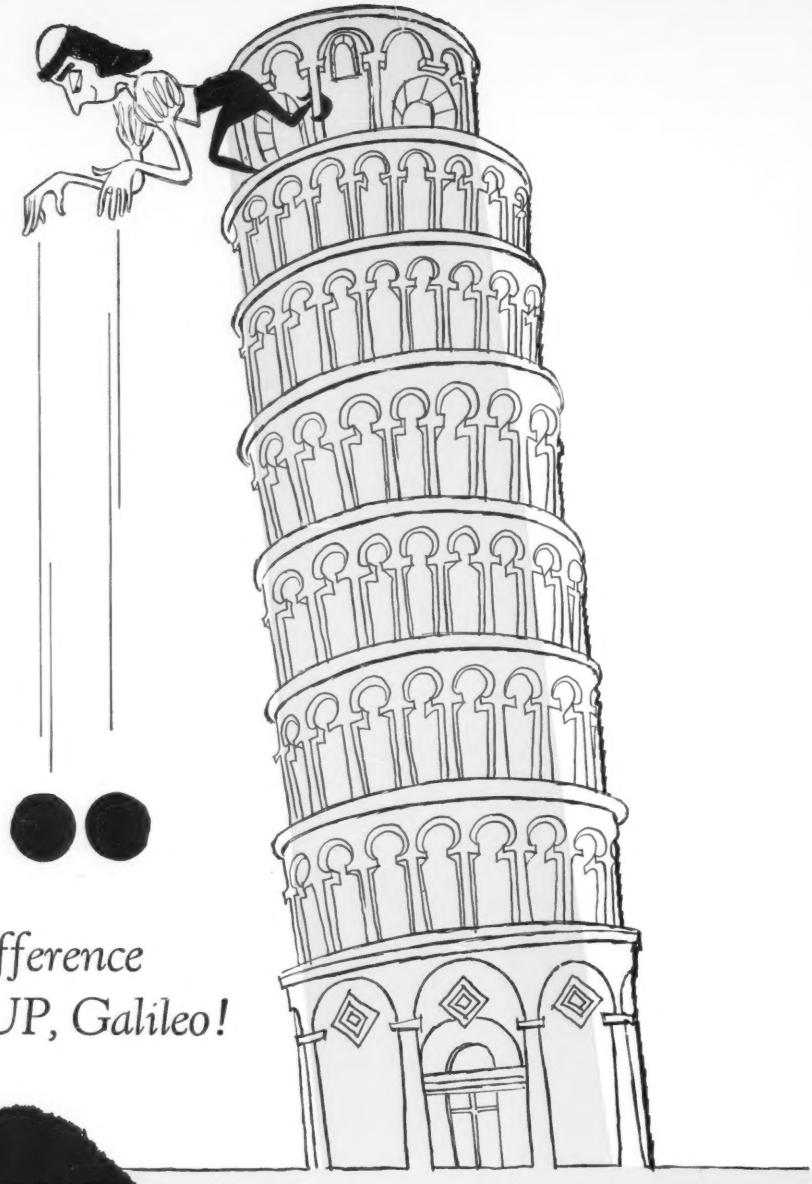
May 1955

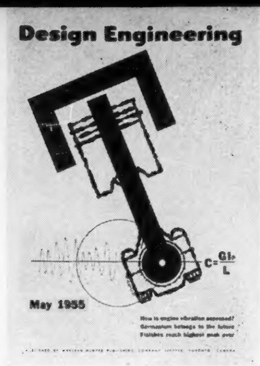
How is engine vibration assessed?

Germanium belongs to the future

Finishes reach highest peak ever

PUBLISHED BY MACLEAN-HUNTER PUBLISHING COMPANY LIMITED, TORONTO, CANADA





This month's cover

This month's cover is more direct than the rambling road that appeared on the April front. Fewer readers will be in doubt about its meaning. Again it was done by artist Don Dancer and was selected from many roughs. It symbolizes the lead feature on torsional vibrations (page 23). The formula shown is an old one, well known to mechanical engineers; it gives shaft torque. The wavy lines symbolize the tracings from a torsiongraph stylus. Behind the piston, the recognized symbol for a cylinder shows. However you look at it, there is no doubt which feature this cover represents.

Design Engineering

Authorized as second class mail by the Postal Department, Ottawa.

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Design Engineering

VOLUME 1 **MAY, 1955** NUMBER 2

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Inside

The June issue of **Design Engineering** will carry strong articles written by contributors no less skilled than those featured on this month's pages.

Printed Circuits is the lead feature for June. All the latest information has been brought together to keep you in touch with this important new technique.

Mylar is a new material you are sure to be interested in. It is fully described and assessed in June.

Unevenness testing is also featured in an article by the Ontario Research Foundation. Don't miss June's **Design Engineering.**

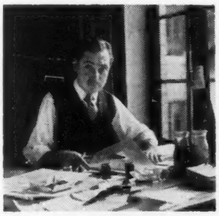
Special Artwork
Editorial layouts designed by art consultant **Desmond English.**

Norton

THE LEAD FEATURE (page 23) in this month's issue was contributed by **Howard W. Norton,** a diesel division engineer in the Dominion Engineering Company. It began as a short feature, but its author's knowledge of his subject is so complete that the story just grew and grew and grew. Howard Norton is well known for his ability to diagnose torsion trouble and is often seen leaving his office to answer an out of town cry for help in a vibration case.

Simkins

ELECTRONICS AND VERY OLD machinery are the two chief interests of **D. S. Simkins,** a product specialist with Rogers Majestic Radio Corporation's commercial division. He writes now (page 32) about germanium transistors and discusses what they mean for the future. In his off duty moments he likes a link with the past through fine but aged automobiles. He comes from Surrey England, has been in Canada for over a year. He would like to see more interest in "vintage" cars in this country and hopes the cult may get going someday.



English

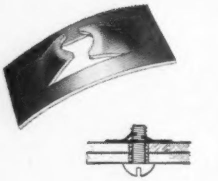
MANY READERS HAVE commented on Design Engineering's layouts. Here is a picture of art consultant **Desmond English** who designs all editorial layouts for the magazine. Well known for his work on Maclean's magazine, Des English is largely responsible for putting the inviting look into Design Engineering.

Farr

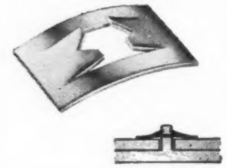
THE CLAIM THAT automobile finishes have taken the science of paintwork to its highest peak ever is made by no less an authority than **Dr. H. O. Farr,** a Ph.D., Physical Chemistry, from the University of North Carolina. He is also vice-president of Canadian Pittsburgh Industries Limited. During the war he was chief of the coatings section of Washington's War Production Board. Dr. Farr believes that for all the excellence of present auto finishes there are many improvements still to come.

design SAVINGS into your product

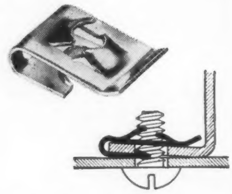
with TINNERMAN Speed Nuts®



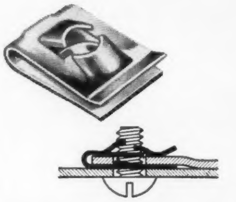
FLAT TYPE — One-piece self-locking spring steel fasteners. Replace threaded nuts, lock washers or spanner washers. Available in a wide variety of shapes and screw sizes.



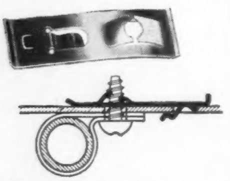
PUSH-ON — Zip over unthreaded die cast or plastic studs, rivets, nails, tubing, or wire to lock parts securely. Removable types available in many sizes.



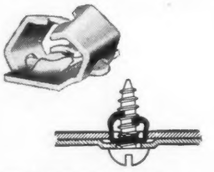
"J" TYPE — Snap over edge of panels and into center hole locations. Hold themselves in place for blind assembly. Full range of panel thicknesses and screw sizes available.



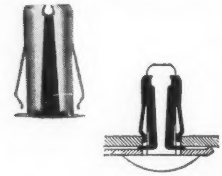
"U" TYPE — Perform same function as "J" type for reduced materials handling. Used where full bearing on lower leg of the Speed Nut is required.



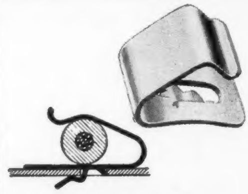
LATCH TYPE — Easily applied by hand, are self-retained in bolt-receiving position at center panel locations for blind attachments. Front mounting types are also available.



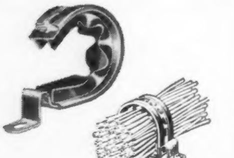
EXPANSION TYPE — For lightning-fast attachments in blind locations. Snap into mounting holes by hand. Screw spreads spring fingers, wedge-locks part in position. Secure, vibration-proof attachment.



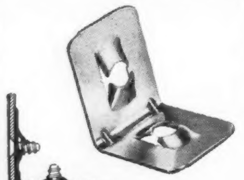
TUBULAR CLIPS — For use with unthreaded studs or rivets. Virtually "nails" panels together where there is access to one side only. Permanent lock or removable types.



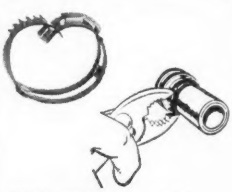
CABLE, WIRE, AND TUBE RETAINERS — Snap in place by hand, self-retained in position to receive wide range of cable, wire and tube sizes. Easily removed for service or re-location.



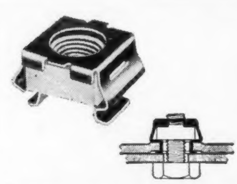
HARNESS CLAMPS — Open or close by hand — no tools needed. Attach to panel or pre-assembly to harness before installation. Cushioned to protect wires. Cannot open accidentally.



ANGLE BRACKETS — Combine bracket and fastener to reduce number of parts, speed up assembly and strengthen the structure. Variety of shapes and sizes.



HOSE CLAMPS — Self-locking, ratchet-type design, one-piece low profile construction — no bolts, nuts or thumb screws. Fast and easy to apply and remove for medium- and low-pressure connections.



NUT RETAINERS — Retain square nuts in blind locations. No welding, clinching, staking — snap in by hand. Provided in a wide range of screw sizes. "U" and "J" type retainers available.

A fastener is an important part of any product. Careful study and analysis of its design and function can greatly improve product quality and lower the over-all production costs. The Speed Nut method of fastening has provided an economical and efficient solution to countless attachment problems. There are more than 6,000 types and sizes of Speed Nut fasteners available for your needs. If necessary a new fastener can be engineered to suit your requirements. Write today for the full Speed Nut story.

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EXCLUSIVE CANADIAN MANUFACTURER and LICENSEE

Reports

News in brief from the world's producers

A PROGRAM to develop methods and equipment for airborne, electro-magnetic surveying is said to be interesting the **International Nickel Co.**

An aerial survey was carried out on certain properties in New Brunswick that had already been explored on the ground by the American Metal Co. Ltd. As a result, lead-zinc-copper ore deposits have been discovered.

• • •

THE FIRST Canadian technical paper competition on welding objects has been arranged by the **Canadian Welding Society.** Its aim is to promote the growth of the welding and fabricating industries in Canada, and to publicize and reward individual and company projects in welding design, manufacture and maintenance.

The competition is open to all those engaged in the welding (or associated) industries in Canada. Eminent authorities on the subject will be the judges.

• • •

WHEN THEIR PRESENT expansion program is completed this fall, **Canadian Steel Improvements Ltd.** believes it will have one of the most modern forging and casting plants in North America.

The company was recently incorporated in the A.V. Roe Canada group and has for long been the main source of supply for forged jet engine blades of steel, inconel and aluminum in Canada.

The new forging equipment will include drop-hammers of up to 10-ton capacity for the production of large components, hydraulic presses for pre-forging billet stock and a number of precision air-operated hammers capable of handling a wide range of forging sizes. A larger metallurgical laboratory is also being built to house a chemical analysis department.

• • •

DETAILS OF TWO big engineering projects being carried out for Ontario Hydro have been released by the **Canadian Westinghouse Company.** The first is an order for eight generators which the firm will supply as part of the St. Lawrence Seaway power installation.

The eight machines will be rated at 60,000 kva, 95% power factor, 94.7 rpm, 13,800 volts and will be umbrella-type units. Each will weigh about 1,200,000 lb with the rotating parts accounting for almost half of this figure. Thrust bearings and brackets will support a combined weight of almost 2¼ million lb. The bearings are the largest ever produced by Westinghouse.

Manufacture of the shafts will set another size record for they will have a larger diameter than any previously built at the company's Hamilton plants. The firm's biggest lathe will be modified to accommodate them.

Two recent Westinghouse engineering developments will be incorporated in the Seaway generators. These will be Thermalastic insulation, which has been referred to as a "once in a decade improvement" and the use of Magamp automatic voltage regulators.

More than 9½ million lb of materials from numerous suppliers will be bought to manufacture the machines.

Of interest from an installation standpoint will be the special outdoor housing arrangement devised by Ontario Hydro engineers. The customary powerhouse will be eliminated with each generator being installed in concrete pits with sliding, weatherproof hatches. Delivery schedule calls for the erection of the first Westinghouse generator to start during October, 1957. Subsequent units will be installed at intervals of 45-60 days. The first machines in may operate as synchronous condensers.

Westinghouse will also build six 55,000-hp motor-generator units for the Sir Adam Beck-Niagara project.

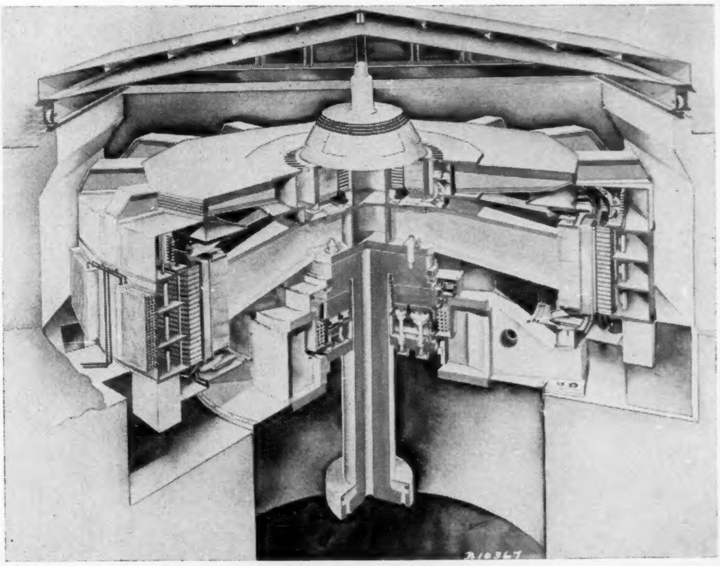
Victim of hangar fire

AT TWENTY MINUTES past five in the afternoon of March 22, an Orenda company guard found No. 5 hangar ablaze. Inside the hangar several experimental aircraft and much valuable equipment were housed.

By the time the flames had been fought down to a smoulder, about $5 millions of damage had been done. The disaster was widely publicized in newspapers and many experts, real and not-so-real, predicted the effect the setback would have on progress at Malton.

Now **Orenda Engines Ltd.,** has made its own assessment and the position is less serious than it seemed. The loss to the company was less than half a million dollars since most of the burned property belonged to the Government. And much of the equipment had already served most of its useful life.

Two experimental CF 100s and a Sabre were lost and these have already been replaced. The Lancaster "flying testbed" which was also lost is not likely to be replaced since new (and still secret) jet engines now in early development stages could not have been tested by this method anyway. As one Orenda spokesman put it: "It had outlived its usefulness. It was not a critical loss by an means."



Canadian Westinghouse's giant umbrella

Letters

• I must congratulate you on the editorial in the April issue, since the subject is very dear to the hearts of many Canadian engineers and mine. Paul Dilworth stated the problem excellently. Canada has the most promising future of any country on earth if its citizens will only have faith in her. They must throw off the chains of conservatism and inferiority and get down to the business of making Canada an industrial nation—designing and developing and producing for her own needs and for export. We do have brains—in fact they are one of our finest exports. We must stop this training and exporting of brains and place the financial faith in our own design and development teams. I sincerely believe that we will all be surprised at the results.

Why should we continue to import and license the fruits of our own engineers living in other countries? They can do as well or better right here at home. Industrial management and our government are, as you have stated, slowly realising this fact. Let them accelerate. They have everything to gain.

B. A. AVERY,
Chief Design Engineer
Toronto.

• The other day the Research Department of Prosthetic Services at Sunnybrook received a misaddressed copy of your new publication DESIGN ENGINEERING. Before being forwarded, it was read with great interest. I would be interested in subscribing to the magazine myself . . .

R. E. GILPIN,
Department of Veterans Affairs
Toronto.

• Mr. Avery's article in DESIGN ENGINEERING (April) is the most interesting technical story I have read in years. He is so right in his argument that the real challenge — the one that makes other problems seem small—is the need for more simplicity in mechanical design.

Perhaps, as he says, the chief need for it comes from the lack of reliability that goes along with growth of gadgetry. Obviously the more moving parts you have to build-in (or on) the more opportunity there is for trouble to develop in service. But there is the other reason of economical production. This is important too.

There are signs that a number of the big Canadian manufacturers are facing up to this riddle of how to make machines which function as efficiently as they should while growing simpler in design. Particularly the electrical ap-

—AND FORGING IS ANOTHER MODERN METHOD

Every word and picture published by a large Canadian daily newspaper for a whole month—all there on a small strip of microfilm. What a space-saving device for the newspaper industry! There are many other modern short-cuts and methods that also cut costs and improve product quality.

A prime example is the way CANADIAN STEEL IMPROVEMENT LTD. have opened up whole new areas in metal forging. They specialize in producing precision products at lower cost. Behind every C.S.I. job is the know-how of highly skilled men with complete facilities at their disposal. That's why the Canadian Government asked C.S.I. foremost in the field, to forge compressor blades and turbine buckets for jet engines.

These same high-quality services—modern, money-saving techniques and skills are available to you. No matter what your product is, or what your problems may be—high temperature alloys, ferrous or non-ferrous metals—commercial, close or precision tolerances—take them to C.S.I. Your requirements will be met. And you'll get a better, stronger product at lower cost.

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pliance manufacturers seem to have taken hold of the theory; at least one of them has literally hundreds of production economy experts at work tearing new products apart to see what can be cut out without loss of performance.

This sort of approach is especially necessary in Canada. In the U. S. the economics of production are different; big runs make it possible for you to take less care. In this country we find ourselves under constant temptation to follow the U. S. and at times appear to forget that our circumstances are not the same.

I believe that if Canada is to play an important part in the world of mechanical design, this is where she should start. Let us be the leaders in the move toward simplicity. Let us not be too impressed by examples of costly luxury from south of the border which keep production costs high and reliability poor.

Mr. Avery and his colleagues are going to take Canadian aviation a long way if the message of his article is put into our aircraft of tomorrow.

JOHN WESTMAN
Windsor *Mechanical Designer*

● My first and remaining impression is that you score on all points. I sincerely hope you can maintain the editorial pace.

My reaction to the front cover, however, was cool. Perhaps it is too vague and not all readers will find the small-type explanation on page 1. If they do, they still may not appreciate your reasoning.

R. M. QUARRY
R. M. Quarry Advertising
Toronto

● I have just completed the reading of your first issue of DESIGN ENGINEERING and find it absorbing and varied in its interests with the design theme excellently represented in all fields.

I am a design engineer employed by the Bridge and Tank Co., of Canada Ltd., and am enclosing a copy of an article published some time ago in Ireland. Possibly you may be interested in it . . .

J. L. DURKEE
Bridge and Tank Co. of Canada Ltd.
Hamilton

Reader Durkee is thanked for his article from Ireland which is now being studied.—Ed.

● After looking through the first issue of DESIGN ENGINEERING I think you have done an excellent job. The cover is stimulating and striking. The table of contents is well placed on a very effective page layout. I like the editorial layout very well—particularly the wider margins and

the way in which editorial material is tied together by shaded frames . . .

The only criticism I have is . . . the NIDC feature. I think it is not sufficiently set off from the advertising on the same page, nor is it tied in with the other editorial material in appearance. However, this is a small point.

The outstanding feature of the magazine in my view is the readability of the editorial material . . . It is very difficult to refrain from reading everything . . . The lead article on jet engines by Mr. Avery is an outstanding example of highly readable technical material. I shall be looking forward to seeing the next issue.

ROY JACKSON,
Ridout and Maybee
Patent Attorneys
Toronto.

● May I congratulate you on your launching of this new venture and for the results of what has obviously been a great deal of planning and a lot of hard work.

I will pass along to you some of the comments of various people on our technical staff. There is a distinct sensation of too much selling in the technical articles. This comment does not apply to the lead article and the feeling is that this and the other articles would have benefited by having the same kind of meat in them.

As a producer of nodular iron, we were particularly interested in the article on pages 54, 55 (Ductile Iron). One comment on this was that this is the kind of information that might appear in a press release and is particularly lacking in the type of specific information that might be expected in a design engineering journal.

You will appreciate that these comments are passed along in a spirit of co-operation . . . With best wishes for your success.

G. R. DUNCAN
Canada Iron Foundries Ltd.
Montreal

● With DESIGN ENGINEERING you have brought a new look to Canadian business papers. Congratulations.

I. S. DECARIE
Aluminum Company of Canada
Montreal

● We had high expectations of DESIGN ENGINEERING from the time the idea was first unfolded on our desks. You should be congratulated because we feel you have lived up to our expectations.

Need more be said? Best regards.

E. C. BRADLY
Ronalds Advertising Agency
Toronto

INCO Research Engineer discussing fabrication of storage vessels with plant personnel of Canadian Vickers Limited.

DOUBLE ASSISTANCE GIVEN IN THE CONSTRUCTION OF CORROSION-RESISTANT STORAGE VESSELS

Let INCO be of service* to you

INCO Research Engineers were able to be of service to Canadian Vickers Limited, Montreal, P.Q., designers and fabricators of 24 large, corrosion-resistant storage vessels for Molson's Toronto Brewery. The correct grade of stainless steel had been selected by Canadian Vickers Limited and manufactured by Atlas Steels Limited, Welland, Ontario. INCO engineers were able to confirm the suitability of this material and render assistance in its fabrication . . . two of the important typical fields of service that INCO offers. For years INCO has put its facilities, personnel and experience at the service of Canadian Industry. If you have a metal selection or fabrication problem, let INCO Development and Research Division, with their fund of information and experience, be of service to you.

**Information involving corrosion, fabrication, foundry problems, high and low temperature service and metals selection.*

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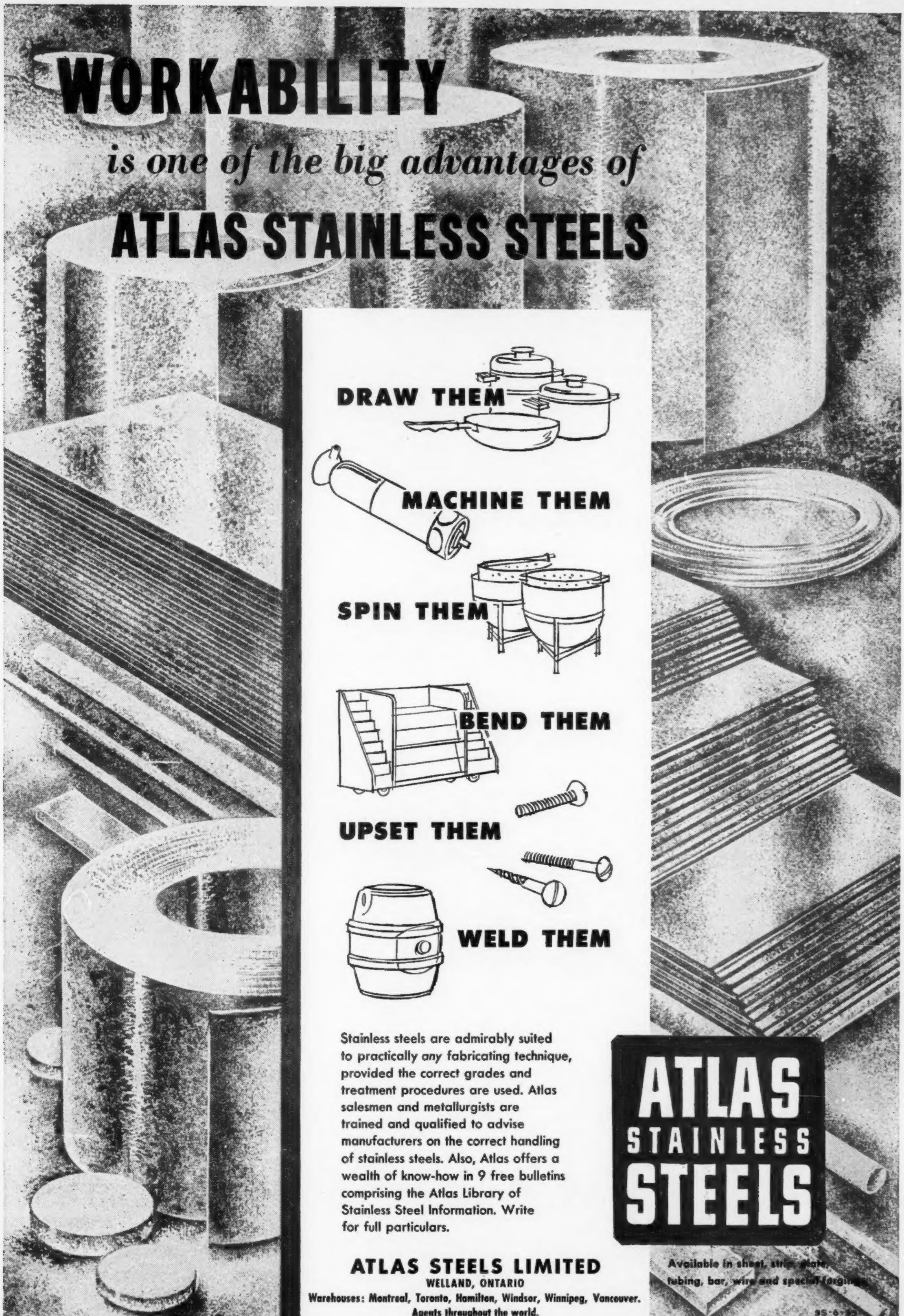
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is one of the big advantages of
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Stainless steels are admirably suited to practically *any* fabricating technique, provided the correct grades and treatment procedures are used. Atlas salesmen and metallurgists are trained and qualified to advise manufacturers on the correct handling of stainless steels. Also, Atlas offers a wealth of know-how in 9 free bulletins comprising the Atlas Library of Stainless Steel Information. Write for full particulars.
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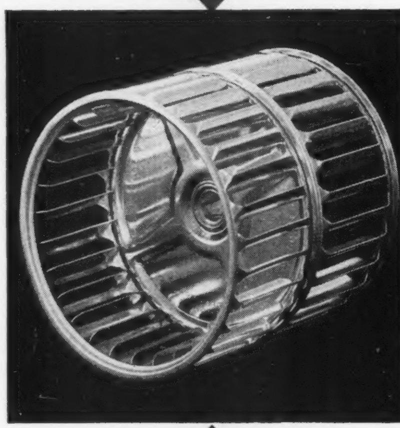
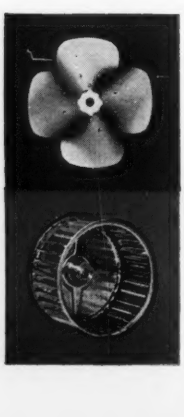
Torrington AIRotor blower wheels are available in three general categories: single wheel, double wheel, (illustrated) and the "X Type" double inlet wheel. Sizes range from 1½" in diameter and ⅝" in width to 11" in diameter and 11$\frac{13}{16}$" in width. Special spline, jaw, or short hubs are also available.



Torrington Airotors represent only a small portion of the unusually broad variety of air-impellers which Torrington is currently equipped to produce for heating, ventilating and air-conditioning equipment. This product range, plus Torrington's great capacity, can provide... quickly and at low cost... the fan blade or blower wheel that's best suited to your air-moving requirements. Torrington also maintains a complete research testing service for assistance on any design problem relating to air flow, sound and vibration. This service is always available to you and can be of particular value in the early stages of product design and development. No one has more experience in the design and production of air-impellers than Torrington. Nowhere else can your dollar buy so much in terms of product quality and customer service.



THE
TORRINGTON
MANUFACTURING COMPANY OF CANADA LIMITED
OAKVILLE ONTARIO
TORRINGTON, CONN. VAN NUYS, CALIF.

VIP's

Important people who are in the news

THIS MONTH, the Engineering Institute of Canada, becomes headed by a new president. **Richard A. Heartz,** president of Shawinigan Engineering Co., has been chosen. Mr. Heartz will find himself at the top of an organization of 16,000 members in 47 branches.

• • •

H. M. TURNER, President of Canadian General Electric Company Limited, has announced the appointment of Vice-President **Ian F. McRae** to head the company's engineering team assigned to design, engineer and construct Canada's first nuclear reactor for power purposes.

Announcement of the undertaking of the nuclear power project was made in the House of Commons recently by C. D. Howe, Minister of Trade and Commerce. Atomic Energy of Canada Limited is responsible for the specifications and cost of the reactor while the Hydro-Electric Power Commission of Ontario is responsible for the specifications and cost of the conventional part of the power plant. Canadian General Electric will design, engineer and construct the reactor, and install and test the conventional electrical equipment involved. C.G.E. is making a substantial contribution toward the cost of designing and developing the nuclear reactor.

Mr. McRae joined Canadian General Electric in 1925. From 1941 to 1950 he was manager of the company's largest plant at Peterborough, where a team of Canadian engineers is being drawn together to implement the company's part in the reactor program. In 1952, following six months on loan to the Government as director, Gun Division, Department of Defence Production, Mr. McRae was appointed a vice-president. He is the present president of the Canadian Industrial Preparedness Association.

• • •

MANY PEOPLE believe that the careful science of engineering and the more abandoned practices of art are seldom joined in one personality. This is not true. Many engineers relax with painting and other art forms.

One Canadian engineer in particular has been winning fame through his paint brush. This is **J. S. Walsh,** graduate engineer and Sales Development Manager of the Dominion Bridge Company.

He has held many one-man exhibitions in Canada and two in the U. S. One of these was a recent showing at the Kennedy Galleries on New York's Fifth Avenue which won a review in Time magazine and the comment that "few painters have handled such (engineering) subjects with more authority." The Montreal Museum of Fine Arts and the Toronto Gallery both have examples of his work in their permanent collections. And some of his pictures have gone to sea. "I believe," he says, "that one or two are ploughing backward and forward across the Atlantic in the new American liner 'The Constitution.' "

Asked by DESIGN ENGINEERING which he thinks is further ahead, Canadian creative art or Canadian creative engineering, he described it as a tough question. "I think there is a great deal of good Canadian creative art but, unfortunately, it is stifled by lack of recognition and interest. Under the circumstances, I have to say that Canadian creative engineering is ahead."

Mr. Walsh is in a good position to judge. British born, he is now a Canadian citizen, is a B.Sc. from London University and served a full apprenticeship with the British Thomson Houston Company.

• • •

ARTHUR A. ALLAN JR. has been appointed sales manager of Bakelite Company, Division of Union Carbide Canada Limited, it was announced today by **Perry Wilson,** president of Bakelite Company.

• • •

THE MAN who might have been acclaimed as the inventor of the automobile died recently in Goderich, Ontario. He was 96-year-old **John B. Kelly.**

In 1884 he built a "horseless carriage" with a top speed of 12 mph. It so alarmed local farmers that Kelly was persuaded to dismantle it. In 1886 a patent was lodged by another inventor and the car was officially born. If Kelly had patented his own machine, he would have made many millions of dollars and a big name for himself. Instead he made no money out of it and won only very localized fame.

He spent many years with the Ontario Hydro as chairman of the town commission and retired at the age of 91.

• • •

CANADA IRON FOUNDRIES LTD., announces the appointment of **G. D. Turnbull** as Manager of Production—Foundries, and of **T. J. Hamilton** as Manager of Production—Machine Shops (Trois Rivieres and Toronto). Mr. Turnbull has been engaged in the supervision and management of foundries since 1928, and was works manager of the company's Fort William plant at the time of his new appointment. His responsibilities will extend to all the company's eleven foundries. Mr. Hamilton has been chief engineer and assistant works manager, Trois Rivieres plant, and is currently director of product development. He will now be in charge of engineering and production of the Trois Rivieres and Toronto machine shops.

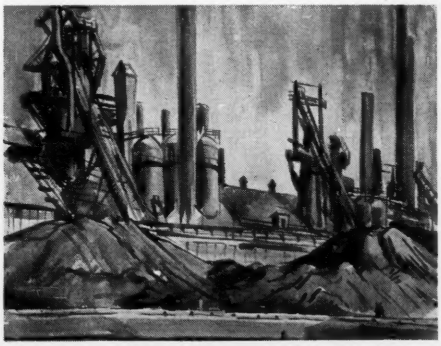
• • •

NEW APPOINTMENTS for two Canadian Westinghouse managers in western Canada have been announced by E. E. Orlando, general manager of the company's District Apparatus Division.

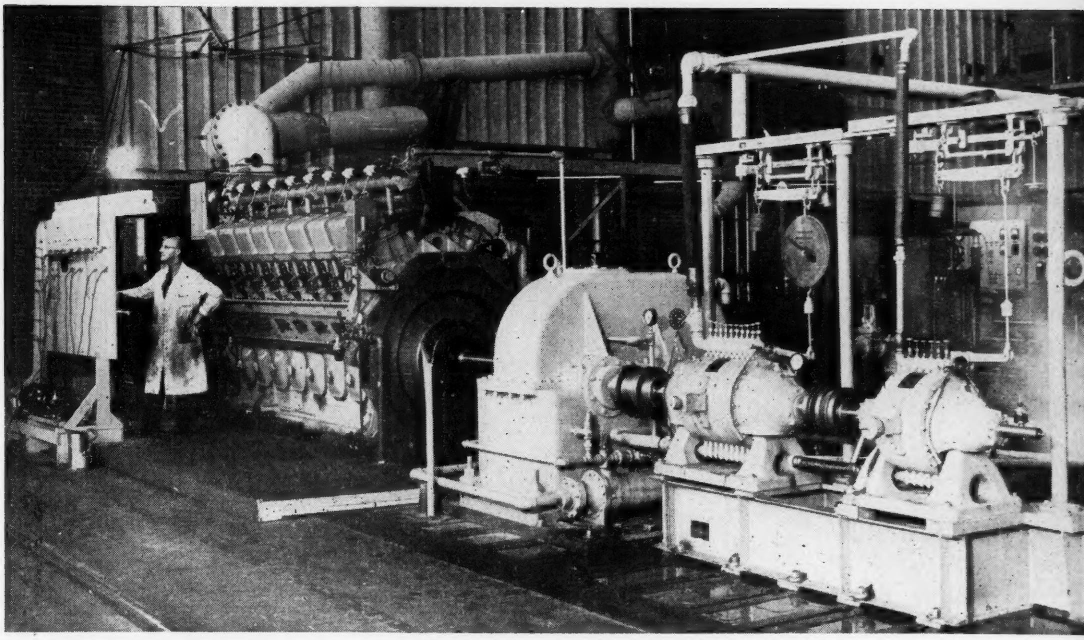
Gordon H. Finch, who for the past four years has been district sales manager at Edmonton, has been named district manager, Western District, with headquarters in Winnipeg. Mr. Finch now heads District Apparatus Division sales operations in the provinces of Manitoba and Saskatchewan and the Fort William territory.

Frank H. Hedley, district manager of apparatus sales for Westinghouse at Trail, B.C. since 1950, moves to Edmonton where he becomes branch manager for the District Apparatus Division.

J. S. Walsh (left)



A Walsh engineering picture


A heavy diesel, like this V-type, must have its vibration tendencies checked. This one is shown on a testbed.

How Do You Check Vibrations in Piston Engines?

By H. W. Norton
Dominion Engineering Ltd.

Vibration in piston-type engines is an old problem. Today's high compressions make vibration roughness more damaging than ever. Here is the way to ensure that engines are properly balanced with their loads.

WHEN EARLIER ENGINEERS built the first big steam engines they walked into a hazard which is with us still. This is the bogey of vibration—the expensive roughness that comes from cyclic torque variation. When diesel engines came along, firing pressures increased and vibration study became steadily more important. In fact, we have reached the stage now where the success or failure of high pressure steam engines and high compression internal combustion engines can be said to depend on the way torsion vibrations are handled.

The best equipment in the world has no hope of giving good service if error or neglect allows strong criticals to be present in the running range; particularly is this so if they are at (or even near) the service speed. And usually engine makers are responsible for making sure that installations are free of torsion troubles.

To hook an engine to a drive by merely checking the horsepower and speed demands is almost sure to give unpleasant results. This sometimes happens with

Continued on next 4 pages

Torsion Vibrations *continued*

stock engines and used engines which are no longer under the care of the maker. In such cases, the contractor assembling the machinery should consult the engine manufacturer (or a qualified vibration analyst) for a complete torsional analysis.

All rotating machinery is subject to torsional vibration for three reasons—which are always present. Elasticity of the shafting, which allows it to twist under applied torque and to spring back upon removal of the torque is one. Fly wheel effect, or polar moment of inertia of masses, such as flywheels, gears, armatures and so on, attached to the shaft is another. Pulsating torque which is produced in varying degrees by different prime movers and which sometimes, though less commonly, comes from the driven machinery is the third.

These three factors can be altered and arranged in many ways. They give machines which at one extreme are smooth and quiet and, at the other, so rough that shafts break, gears strip and foundations crumble.

This roughness is measured in terms of the amount of angular displacement (twist) of the rotating members against the mean position they would hold if they rotated with a constant angular speed. This displacement is alternately positive and negative; a peak torque causes a positive or leading displacement and then the restoring moment due to shaft wind-up—proportional to displacement—causes the swing back to a negative or lagging displacement.

In a vibrating two mass system, the two masses swing oppositely and there is a point along the shaft at which there is zero amplitude. This point is called a node and the vibration is said to be of the one-node mode or of the first frequency. But if there is a third mass in the system, the end masses can swing against one another or they can swing together in opposition to the centre mass. In the second case, there are two nodes, one in each section of the shaft, and the vibration is of the two-node mode or of the second frequency. It follows that, in a system of masses, there can be from one to (n-1) nodes and the same number of frequencies. The frequencies are measured in cycles per minute, the one-node mode having the lowest frequency, the two-node mode a somewhat higher frequency and so on, up to the highest node.

If the output torque of the engine and the resisting torque of the driven machine were quite uniform, no torsional vibration could be set up and the only twist in the shaft would be from the constant torque being transmitted. But it needs only a slight torque variation to set up torsional oscillations. This is the trouble; and it is particularly true if the frequency of the periodic torque variation happens to coincide with the frequency of one of the nodes of torsional vibration.

It is the variation of tangential effort (and so torque) over the cycle which causes torsional vibration. (PICTURE 4). During the power stroke in a four-stroke cycle, the gas pressure changes as the crank rotates from top-dead-centre (where there is no turning moment) through a position before mid-stroke where there is optimum mechanical advantage, but reduced pressure, and on to bottom-dead-centre, where there is little pressure and no turning moment During the other strokes, there is less variation of gas pressure but the torque due to inertia variations modifies the net tangential effort during all strokes.

The tangential effort curve repeats itself every cycle and can be considered as composed of the algebraic sum of the mean tangential effort and a series of harmonic components. These harmonic components are found by means of a Fourier series.

Typical harmonics of a four-stroke, single-acting, internal combustion engine are shown (PICTURE 4). Only the first four orders are given.

It will be seen that the wave length (or period) of the fundamental vibration takes two revolutions of the engine and since the order number of a vibration is the number of vibration cycles in one complete engine revolution, it follows that for a four-stroke engine, since there are two revolutions per working cycle, the fundamental vibration is a half order vibration. Similarly, this engine also excites vibrations of the 1, 1½, 2, 2½ . . . orders. The two-stroke cycle engine, by the same reasoning, excites only vibrations of whole number orders.

The harmonic coefficients of most standard type engines need not be computed in each case because they can be got directly from published data. Such varied types as two and four-stroke, single-acting, gas and

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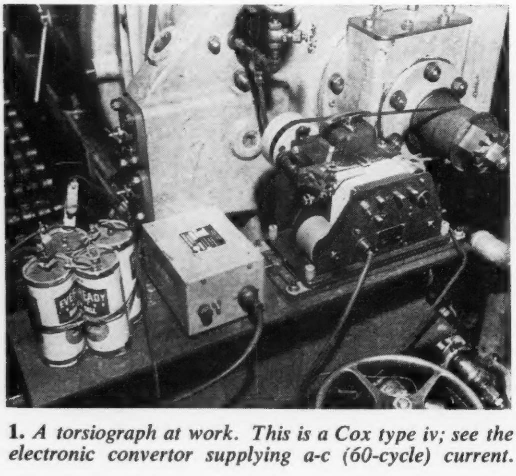
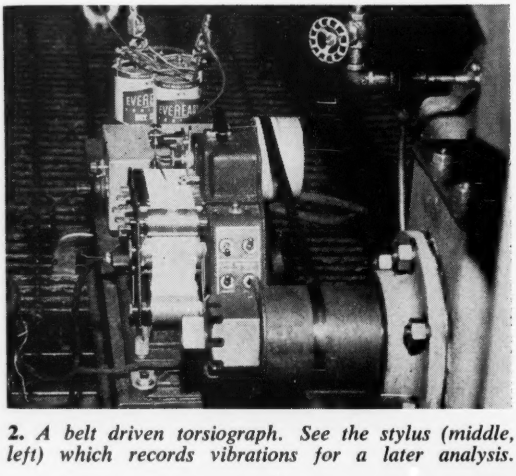
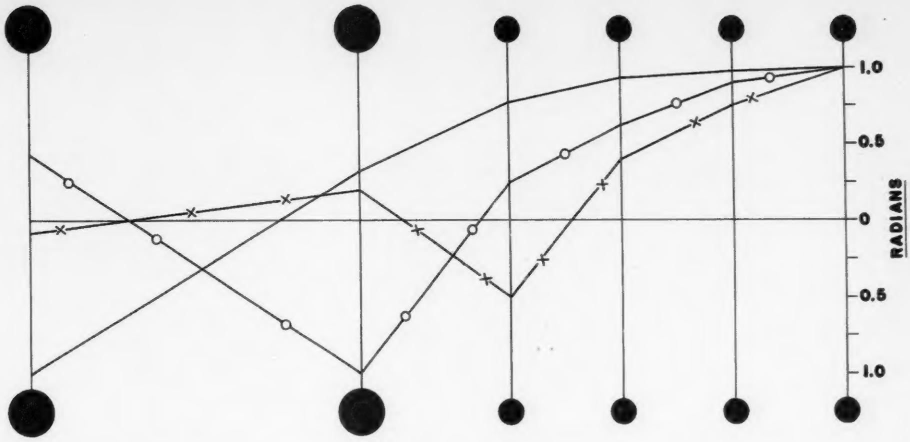


1. *A torsiograph at work. This is a Cox type iv; see the electronic convertor supplying a-c (60-cycle) current.*

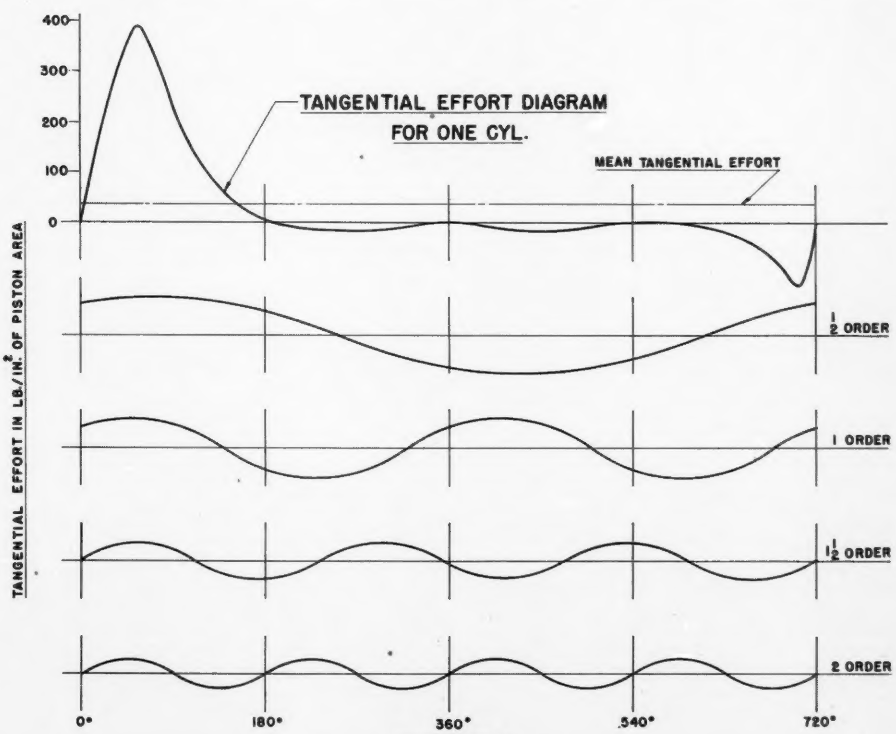


2. *A belt driven torsiograph. See the stylus (middle, left) which records vibrations for a later analysis.*



3. *Small dots (right) engine masses, large centre dots flywheel, left dots generator rotor.*

'Large amplitudes can pound out big ends, main bearings and rotors . . .'



4. *Typical harmonics of a 4-stroke single acting Ic engine. Only first four orders shown.*

Torsion Vibrations *continued*

diesel engines, two-stroke, double-acting, diesel engines and various two-stroke opposed-piston diesel engines are covered. Care should be taken to choose coefficients which most nearly fit the individual case for the ratio of crank length to connecting-rod length.

As for excitation starting in the driven machinery, the same broad principles apply. A frequent case is that of the marine propeller; it oftens faces a variation of resisting torque as each blade sweeps past the rear of the hull. Electric generators on the other hand, produce a torque reaction which can be taken as uniform.

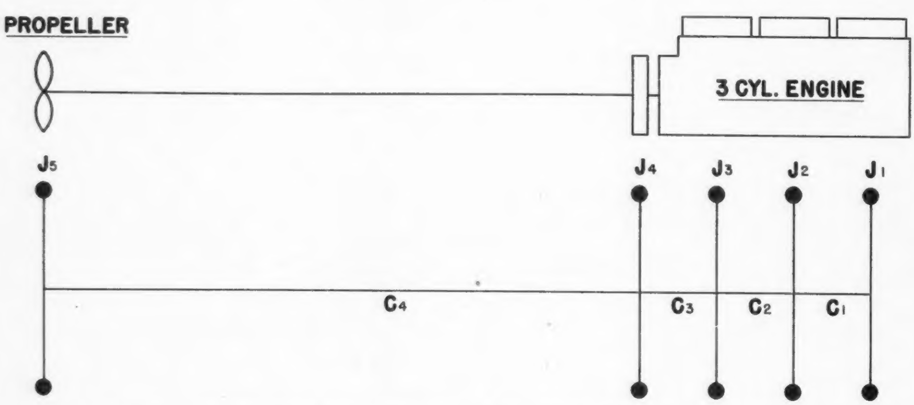
The effects of wild torsional vibration are many; but they may be split into three main classes. First, large angles of twist in the shaft, giving torsional fatigue of the shaft and its eventual breakdown. Shafts affected in this way include crankshafts, generator shafts, propeller shafts and so on.

Second, large amplitudes at take-off for auxiliary drive, resulting in damaged gears, broken chains and rough camshaft operation. And last, large amplitudes along the engine crankshaft which pound out big end connecting rod bearings and main bearings, while pole pieces of generator rotors can be shaken loose for the same reason.

To be sure of smoothness it is necessary to make a complete torsional analysis of each proposed arrangement. After working out the shaft stiffnesses and polar moments of inertia of the masses an equivalent mass-elastic system for use in calculation is chosen. In the case of geared drives, all masses and stiffnesses can be stated in terms of engine speed, by multiplying these values by the square of the ratio of their speed to the engine speed.

Calculation of the natural frequencies then has to be faced. Two methods are in general use for multi-mass systems: the Holzer method and the Reduction method. Both are briefly gone into later.

Using the results it is now possible to find the relative amplitudes of the masses, the relative moments in each section of the shaft and the relative stresses in each section of the shaft per degree of amplitude—the free end of the crankshaft usually being taken as having unit amplitude in ordinary cases.

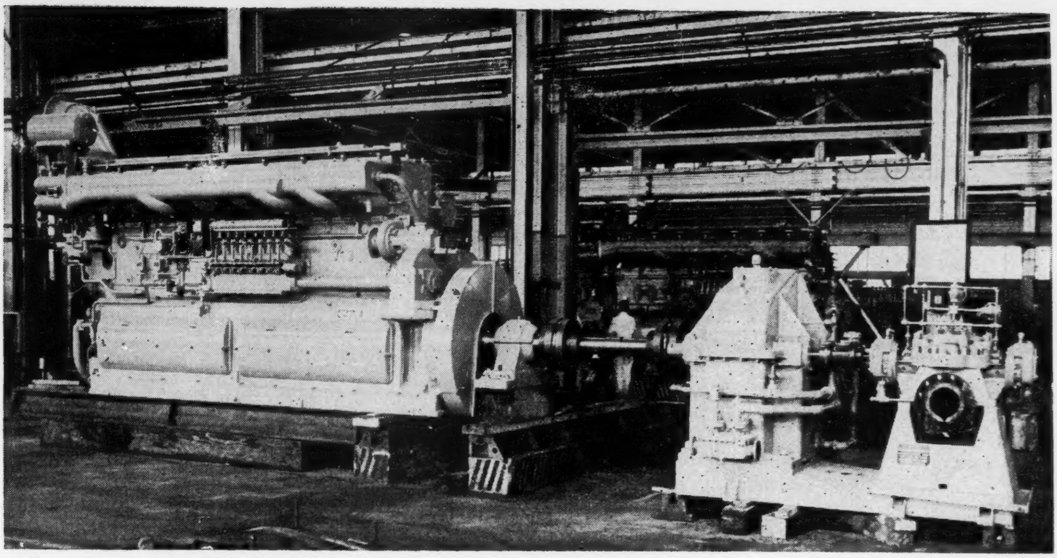


5. *An "idealized" diagram of a system taking engine and propeller effect into account.*

'Calculation of the natural frequencies then has to be faced and solved'

1	2	3	4	5	6	7	8
MASS	MOMENT OF INERTIA	TORQUE PER UNIT DEFLECTION	DEFLECTION	INCREMENT OF TORQUE	TOTAL TORQUE	SHAFT STIFFNESS	CHANGE IN DEFLECTION
	J LB.-IN.-SEC.^{2}	$J\omega^2$ IN.-LB./RADIAN	θ RADIANS	$J\omega^2\theta$ IN.-LB.	$\Sigma J\omega^2\theta$ IN.-LB.	C IN.-LB./RADIAN	$d\theta$ RADIANS
NO.1 CYL.	7·14	1·284	1·0000	1·284	1·284	41·4	·0310
NO.2 CYL	7·14	1·284	·9690	1·244	2·528	41·4	·0610
(Abbreviated Table)							

6. *Holzer table for the first mode. All headings are given but only some of the values.*



This smooth-running diesel pumps crude oil. It was properly matched to its load by the method described.

The next problem is how to find maximum amplitude? Again two methods are in general use. If Holzer tables are used to calculate the frequencies, the maximum amplitudes are found by multiplying the equilibrium amplitudes by the dynamic magnifier. If the Reduction Method is used to find the frequencies, the energy input to the vibration is equated to the energy dissipated in damping. Since the maximum amplitude appears in the expression, a numerical value corresponding to each order of vibration can be taken out.

Let us now take a look at solving the general case, using the method associated with Holzer tables. The stiffness of each section of the shaft — assumed circular — between significant masses is calculated in inch-lb/radian.

If $G =$ modulus of rigidity (11.8×10^6 psi for steel).

$I_p =$ polar moment of inertia of shaft cross-section (in.^{4}),

$L =$ length of shaft (in.) then

$C =$ stiffness (in.-lb/radian)

$$= \frac{G\,I_p}{L}$$

When there are several diameters of shaft within the length being studied, the stiffness C_1, C_2, C_3 and so on are found for each diameter and the over-all stiffness is arrived at through the relationship

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$

The effective length of a given section of shaft depends on how much the shaft penetrates into coupling hubs, or other parts, before the oscillatory motion is completely given over to the rotating mass. Judgment, based on experience with similar cases, is needed here, particularly where the shafting is short and stiff. Good average allowances are given (PICTURE 3).

The crankshaft stiffness, allowing for the discontinuities at the webs and the fact that the crankpins and journals may or may not overlap, can be found from empirical formulas given by Carter, Geiger, Timoshenko and others. Usually, however, an accurate value is obtained for a particular engine from a torsiograph test (see details later) on an installation in which all values other than the crankshaft stiffness are well known. Fortunately, once the crankshaft stiffness and WR^2 values of an engine have been obtained and found correct, they can be used in future problems.

The next move is to find the moment of inertia of the rotating masses, the method here depending on the particular setup. Simple flywheels and gears are easily handled. Values for generator rotors, pump impellers and marine propellers are usually supplied by the manufacturer. In the case of pump impellers and marine propellers, an allowance (usually 25% of the specific gravity) must be added for entrained fluid.

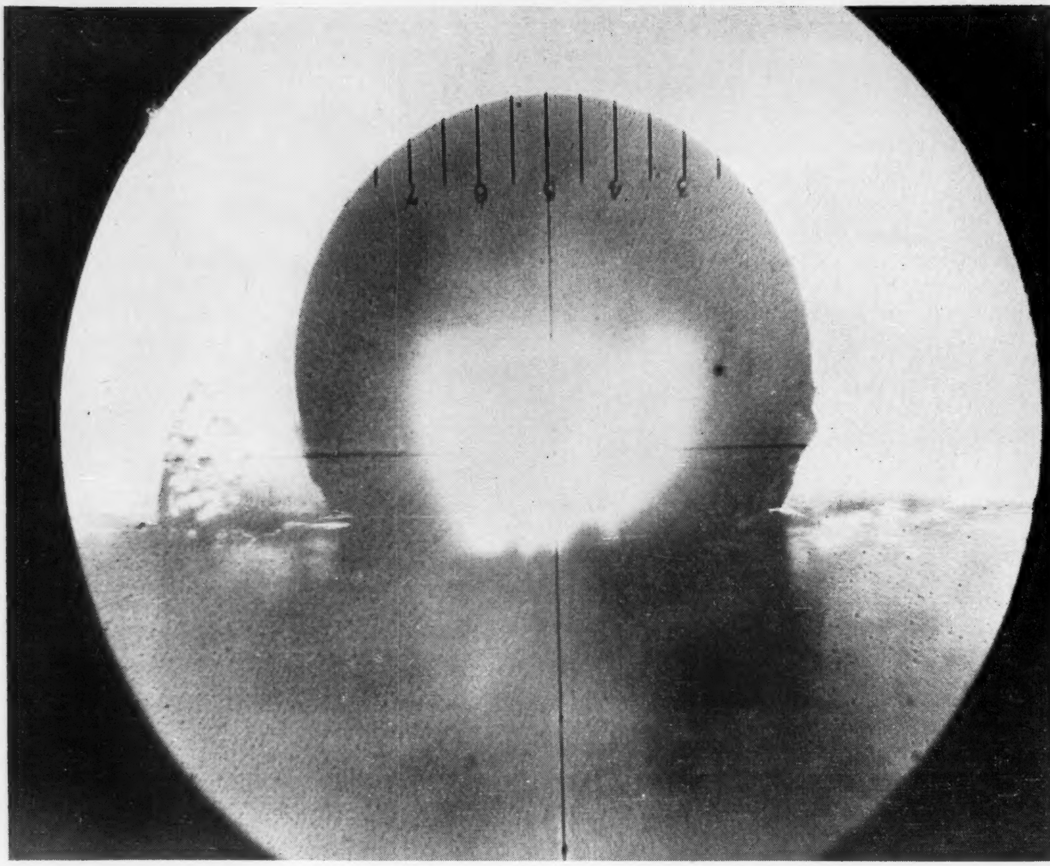
A more involved process

The value to be used for the working parts acting on the crankpin of an engine is arrived at by a more involved process. The connecting rod is considered as being replaced by two masses, acting at the crankpin and piston pin, having values that are inversely proportional to their distance from the centre of gravity of the rod. The part at the piston pin is added to the piston weight and one half the sum added to the other connecting rod mass at the crankpin. The product of the total times the square of the crank radius gives the equivalent WR^2 of the piston and connecting rod. If this is added to the WR^2 of the crankpin and crankweb, the total WR^2 at each crank is obtained.

We now have sufficient information with which to calculate the natural frequencies. A diagram of the idealized mass-elastic system representing the machine is usually drawn for convenience (PICTURE 2).

A Holzer table (PICTURE 6) for the first mode is next set up using the numerical values for moments of inertia under column 2 and shaft stiffnesses under column 7.

At the outset the Holzer table is set up trial and error. An estimate of the first frequency of torsional oscillation of the whole system (in this case 4050 vibrations per minute) is made and this, divided by 9.55, gives the angular phase velocity $\omega = 424.1$ radians per second.



A much magnified photograph of a water droplet on a thin silicone film. Note the very small spread.

Let Silicones Protect Your Bearings

Engine design progress can be said to rest on good lubrication, as speeds loads and temperatures give bearings even tougher stress-tests. Petroleum oils collapse too soon. So silicones are taking over.

By Frank Chatterton

WATER CANNOT "WET" a silicones covered surface. A simple test shows this to be true and points to the first value of silicone oils. Put a drop of water on silicone film and see how high it stands and how little it spreads. Here then is a good weapon to fight off the attack of water condensation in engines.

But the story of silicone oils goes much further than this. The modern engine runs hot—much hotter than it used to and temperatures are going up all the time. One of the most difficult jobs is to get bearing lubricants that work at top heat and yet stay liquid at the low temperatures of the stratosphere. Part of the answer comes from sand; silica compounded with hydrocarbons gives silicone oils with good viscosity stability at both high and low temperatures.

Unfortunately, these oils have had some faults that ruled them out in just those cases where their root properties should have made them ideal. Silicones have poor wetting properties. Because of this they have not stayed put on surfaces when loads became high or speeds excessive.

So, other lubricants were developed, which, though lacking the ideal temperature characteristics of the silicones, did a better job under high-speed, heavy-load conditions. The most widely used of the liquids in this

category are the aliphatic diesters, which are used universally in jet engines.

But there were still snags. The useful organics, when exposed to too much heat, left deposits which seized up the bearings, or left a varnish on them which was hard or impossible to lubricate. This problem was answered by polyalkalene glycol lubricating fluids. These do not decompose in heat to form harmful substances, but are converted into gases or more fluid liquids.

Then, as the problems of heat control become tougher, the road always seemed to circle back to silica. So it is today. Modern halogenated silicone oils have recently been announced, which retain the old viscosity stability, but provide new load-bearing high-speed lubricity. These oils (which are discussed later) are new and they promise to open new design thinking from their unusual physical properties.

There are other approaches

Of course, there are a number of other approaches to the high temperature lubrication problem. As with the silicones, halogens are being checked closely, and put to a variety of uses. A very high temperature, non-inflammable type of fluid (even the silicones have a flash-point), is now being made with the halogen, fluorine. These fluorinated hydrocarbons are another useful form of lubricating liquids.

The pressing nature of the modern lubrication problem has led to study testing on a large number of unusual compounds. These are best looked at here as families of compounds instead of separately. Silicones stand very well as basic liquids against which other high temperature lubricants can be compared.

The silicones are outstanding examples of new synthetic oils. For instance, a DC 200 methyl silicone oil having a viscosity of 9.2 Cs at 210 deg F, has a viscosity of 170 Cs at —40 deg F. In contrast, a low viscosity-temperature coefficient petroleum oil (AN-O-6a), has a viscosity of 10.0 Cs at 210 deg F (almost identical to the silicone) **which increases to 4,000 Cs at —40 deg F.**

The regular silicone oils provide excellent torsional vibration dampeners, good bearing lubricants for most metal pairs, excluding cast iron against steel, and steel against steel. They are excellent plastics lubricants, being used in plastics cutting and drilling, mould release, and in the lubrication of nylon bearings. They are excellent liquid dielectrics and outstanding water shedders. As noted previously, they have the power to improve other synthetics, particularly by preventing foam. And they are relatively unaffected by the ravages of air at high temperatures. (Petroleum is subject to this kind of decomposition, and even though oxidation additives are used with it, it does not approach the silicone behavior).

But they have weaknesses too. Because of these, their use in such parts as jet aircraft bearings has been limited. Silicones, in the forms being sold so far have had poor lubricating properties between ferrous bearing surfaces. Their coefficient of friction has been somewhat high—.33 as compared to .14 to .16 for good petroleum oil. This has resulted in a high rate of wear.

As a result of these weaknesses, aliphatic diesters are now most commonly used as low temperature-coefficient lubricants in jet engines and other similar applications. These oils operate satisfactorily in the temperature range from —65 deg F to 285 deg F. The latter heat is experienced in the main bearings in flight. Soon after shut-down engine temperatures rise to as high as 500 deg F. This is caused by the flow of bearing heat which is largely dissipated in flight.

The diester oils have relatively high load bearing capacity and good wear characteristics. This is increased by the addition tricresyl phosphate. They have good oxidation resistance, but this is usually increased by the use of additives. They are relatively unaffected by small traces of water, though anti-rust agents are incorporated into them to prevent rust of bearings in storage. These agents are the same as used for petroleum. Small percentages of silicone oils used with them, to prevent their tendency to foam in use.

Like the silicones, the diesters are high in cost. So their use in industry is limited to those times when

Continued over page ▶

What is Wrong with Petroleum Oils?

TO UNDERSTAND the value of the newer synthetics, it is first necessary to know what is wrong with petroleum oils: The best of them will work only fairly well in the temperature range of —40 deg F to 250 deg F. At the high temperatures they decompose too quickly forming tarry substances which deposit a kind of varnish over the surface of the bearings. When this happens, friction raises the heat further, gumming takes place quicker and there may be fire if the high heat causes the oil to flash.

At the low temperature they become very viscous. This means starting torque is very high. Other disadvantages of petroleum oils are their power of dissolving or weakening gasketing material, particularly rubber—and the fact that many foreign liquids mix with them, to damage their lubricity. Another often-overlooked petroleum oil weakness is the difficulty of keeping it uniform. Coming from a wide variety of crudes, the oils differ in composition, though their physical aspects may appear identical. This results in varied working properties which are often impossible to control.

The synthetics—mostly at relatively high cost—have overcome these problems. Without them the age of jets and small electric motors would have been impossible. Today, advances in lubrication technology are made mostly on comparisons between new and previous synthetics, rather than to petroleum oils and greases.

what they do matters more than what they cost. Lubrication instruments, timing devices, sewing machines, and fishing reels are examples. They also have many important military uses. Among them are small arms and machine gun lubricants, and damping and other liquids for use in aircraft instruments.

Another limiting factor in the aliphatic diester synthetic lubricant picture has been scarcity of raw materials. The most important raw materials cost-wise have been dibasic organic acids. These were derived from sources such as castor oil, of foreign origin. Today this situation has been largely corrected. Prime sources of these vital materials are now exemplified by such commonplace substances as coal, petroleum, oats, stockyard fats, and turpentine.

Another group of interesting tailor-made synthetic oil is classified as polyalkalene glycol. A series of oils are made from this derivation having pour points as low as —70 deg F. They are useful for high temperatures—particularly in combination with graphite. They have unusual characteristics which mark them off from all other synthetic lubricants. When operated at temperatures high enough to make them decompose, they do not form sludge, tars, or varnish-like residues. The decomposition products are liquids similar to the original lubricants, or gases which pass off into the air. In addition they have the power to mop up decomposition products from other lubricants—in particular petroleum oils. So when used in machines which contain deposits from other lubricants, they have a fine cleaning action.

Also in the polyalkalene glycol derivative family are the water soluble oils. These were developed to meet lubrication needs, where fire hazards exist. In addition to the polyalkalene glycol, they contain water, ethylene glycol, and corrosion inhibitors. Low temperature operation limits are —40 deg F, with upper limits dictated by the boiling point of water. As might be expected, they have little damaging effect on rubber and gasketing material due to the high water content. It is also interesting to note that viscosity can be controlled by the addition of water, and spillage is very easy to clean up.

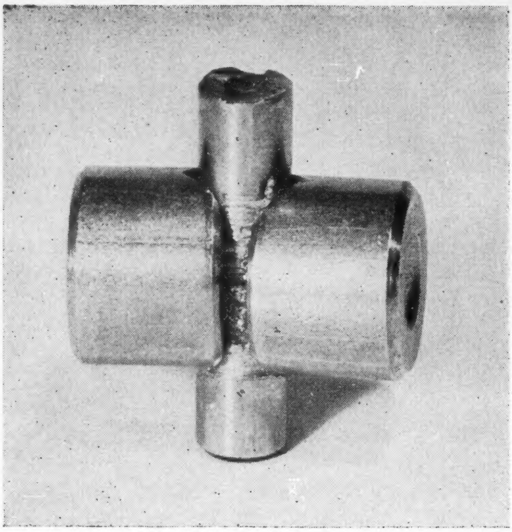
Glycol lubricants used in aircraft

The water-base polyalkalene glycol lubricants are used as aircraft landing gear fluids and in brake and flap control hydraulic systems. Being non-inflammable, they do not add to fire hazards when used in commercial aircraft hydraulic liquids, or in military aircraft when hydraulic systems are hit by bullets.

But attention has swung back to silicones again. Keen research has been going on to improve silicones weaknesses. A few months ago, Gordon Gainer of the Westinghouse Corporation reported success with some amazing new silicone lubricants.

These are the halogenated silicones. Halogens (chlorine, fluorine, bromine) were combined with the methyl and phenylmethyl groups in the original silicone oils. This gave a marked reduction in friction coefficient and Falex wear and made the oils usable on ferrous surfaces which before needed the ester (or other) synthetics. The development was completed in 1950 but was only very recently made known.

In the new halogen silicones, fluorine was found to give the best over-all results, with two halogen atoms in the molecule being better than one. Load bearing properties of the new products have been much improved. Seizure from overloading was assessed by the Falex antiweld test. In this test, if a total load of 2,500 pounds gage is attained without sudden increase in torque, the test is stopped and noted as having been passed. In two runs, the actual bearing pressures involved when the test was stopped were estimated by measuring the width of the scar on the V block. These were found to be 31,250 pounds per square inch, and 33,333 pounds per square inch. But when heavy, medium, diesel, turbine engine oils of high quality were used in the test, welding occurred at very low pressures.



A petroleum oil "weld" failure during a Falex test.

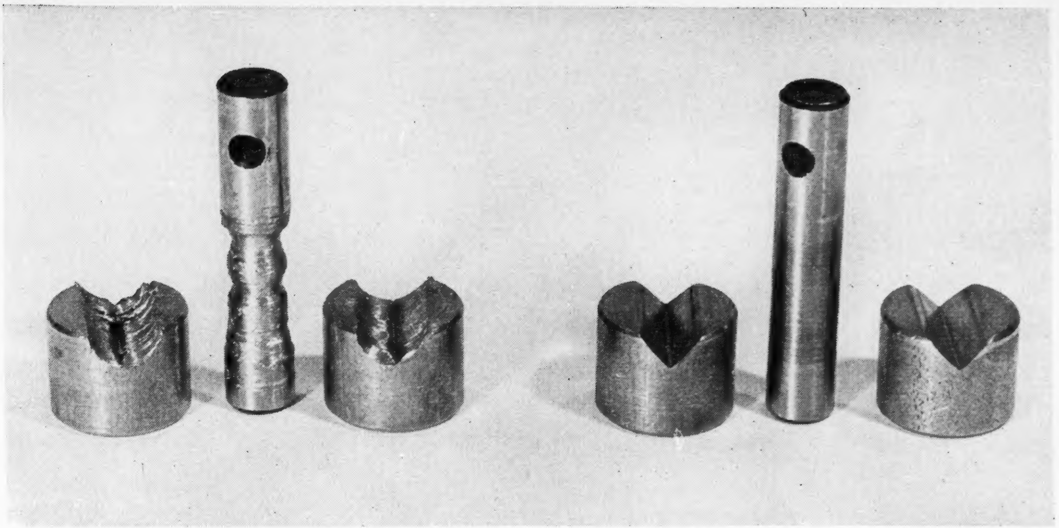
Petroleum oils earned a poor rating by

The new silicones were tested for ageing qualities at temperatures of 347 deg F, 392 deg F and 437 deg F. In three samples, strips of copper, aluminum, and SAE 1010 steel were immersed, while a fourth was used as a control. If anything, Falex wear rate is improved at any test temperature used. No metal materially changes the oils, though contact with copper slows down the viscosity increase slightly. Tests were run mostly, for periods of over 2,000 hours. No anti-oxidant tested improved the stability of the original samples.

The result of this work is the creation of several new fluids that appear to be the answer to the problem of high temperature stability applied to gas turbine engines. The work is continuing and additional progress reports will be made later.

There are a variety of other high and low temperature lubricants still in limited use, which have great potential value. Many of these are closely related to plastics chemically. They are liquid polymers made basically from plastics raw materials, or "monomers" as they are called. These products are made by stopping the setting or "polymerization" of the monomers before solid substances are produced. Other types are made by reacting organic acids with alcohols. Many valuable discoveries are sure to be made from the widespread investigations now going on.

Greases are made by blending thickening agents with oils. The traditional agents for this purpose have



A Falex failure, left, from dimethyl silicone oil. On right, no wear from p-bromophenylmethyl silicone oil.

the Falex antiweld test; but with the right silicone oil, perfect results came up.

been soaps. Sodium soaps (water soluble grades normally found in the home) blend with oils to form greases having a fibrous nature. Calcium soaps are not water soluble. These are formed (by way of illustration) when household soap contacts water, forming a white insoluble cloud. This cloud is calcium soap coming from reaction with lime dissolved in the water. Combined with oils, calcium soaps form smooth buttery greases. Lithium soaps are water insoluble too. They came out in World War II and were used to make water repellant greases useful at temperatures up to 300 deg F. These products have excellent low temperature properties, and high cost. Barium soaps are like lithium.

As soaps are made by chemical unions of oils or (oil derivatives called fatty acids) with metals, the fatty portion of the compound is important also. Recently the fatty acid coming from castor oil has been made into a modified product having outstanding properties. This is known as 12 hydroxy stearic acid. In combination with the normal metals, it extends the temperature range at which greases will operate.

With the never-ending search for greases capable of working at higher and higher temperatures, a constant development of better thickeners has been made necessary. Though not yet available commercially, arylurea thickeners are noteworthy examples of such products. In combination with suitable silicone oils, these thickeners have made greases possible which work through the range of —40 deg F to 450 deg F. With certain of the newer silicone oil developments this range has been increased experimentally to —65 deg F to 450 deg F.

The greases have been lacking in three characteristics which can be traced to the base silicone oils. Low temperature torque is not yet completely satisfactory; poor wear properties were evident (though the greases gave outstanding performance in the ABEC-NLGI bearing tester at 450 deg F, with several of them consistantly exceeding 600 hours); and lastly, viscosity is high.

Despite the drawbacks, arylurea greases are finding many exciting uses. No reports have been published yet on their behavior with halogen-modified silicones. But it seems obvious that the extended-range products (—65 to 450 deg F) were made using these new liquids. Probably combinations of this sort give greases having the closest approach to the ideal.

A need is already seen for an ultra-high temperature grease giving satisfactory performance at 700 deg F. There are no oils yet available which will work at this high temperature, so that possible thickeners are now being tested. An onium bentonite salt known as Bentone 34 is getting much favorable attention for this job. This is, in effect, a kind of clay which is similar in physical behavior to soap while retaining clay's resistance to heat. It has been found that about 28% of this thickener is needed to get most oils to a point of suitable consistancy. Such greases have good resistance to bleeding out of the oil and the Bentone 34 has no effect on oil evaporation. Oxidation resistance by the oxygen bomb test is good, and wear tests show satisfactory performance. Good lubrication as low as —65 deg F has been obtained with this thickener using low temperature base oils.

There is a drawback

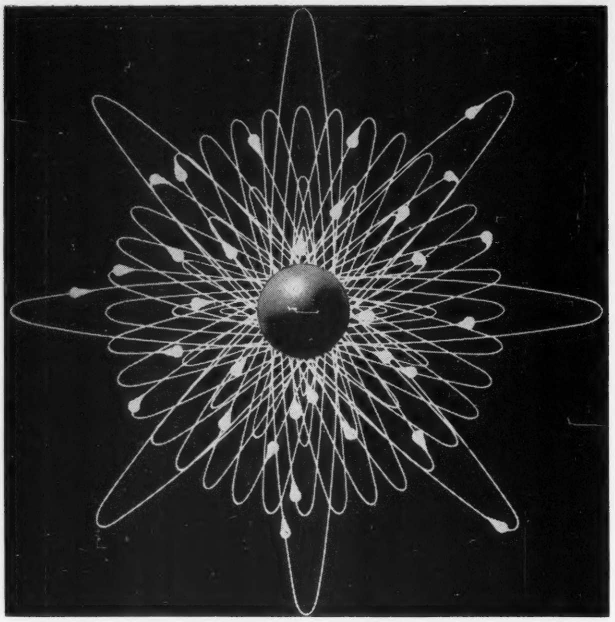
The one drawback of the Bentone 34 greases so far is their rather poor rust inhibiting properties. High speed lubrication is somewhat lacking too. However, there is every indication that present testing will turn up additives and combinations that will beat these problems. Certainly, for the very high temperatures to come, this onium bentonite has the most promise of any grease thickener. Of course, other thickeners like silica gel can be used at high temperatures too. However, as would be expected, there is a high wear characteristic with this thickener, which seems independent of the oil used.

Of all high temperature additives, graphite has given the longest and most consistently good results. Being a lubricant itself, an improver for oils, and a grease thickener for half a century, we are apt to overlook this wonderful material.

For high class applications, the natural graphite

(Continued on page 71)

Something new turns up in electronics almost daily. Now the germanium transistor has come; it rates as a real discovery which is sure to simplify many future products



By D. S. Simkins
Rogers Majestic Radio Corp.

Germanium's atom has a positive nucleus, an orbital number of 32 and four layers.

Electronics Takes Another Forward Step

THE SCIENCE OF ELECTRONICS is now in high gear. Almost every day, something new is listed and developed for industry. Many of these forward steps have came from fuller uses for the classic thermionic vacuum tube.

Less often, a device which is entirely new—something you can call a discovery rather than a development—comes along. A recent one of these is the semi-conductor, in the form of a transistor. The little product can do most of the things a vacuum tube can do; but it does more besides.

The semi-conductor itself it not, of course, by any means a new idea. Early radio sets used a semi-conductor in the form of a crystal of silicon or other material, together with a conductor known as the cat's whisker. To get contact between the two was very tricky, as users will well remember.

The transistor, like the vacuum tube, works from the motion of electrons, with the difference that this electronic action takes place not in a vacuum (as it does in a tube) but in a solid state modified by "holes."

The action depends on the atomic lattice structure of some solid elements, the most notable of which is germanium.

Germanium, which is found in the earth's surface in small quantities, has an atom which consists of a positive nucleus surrounded by a specific electron structure. In this particular atom the orbital number of 32 is made up of four distinct layers, respectively 2—8—18—4. Of these the first three are so tightly married to the nucleus that they do not affect the electrical or chemical properties.

The four electrons in the outer layer are the valence* electrons which form the links with adjacent atoms. In the pure state germanium is balanced and so stable, and because of this is a poor conductor; but the presence of even minute quantities of impurity alters the conductivity and behavior of the solids.

To turn germanium into a good conductor free electrons must be provided and this is done by the controlled addition of a minute impurity, such as antimony. The resulting product can become a high-sensitivity but low-current-handling semi-conductor—stable enough to allow the cat's whisker to be fixed permanently to the crystal.

Only four electrons taken up

Antimony is an element having five valence electrons so that when it is added to germanium only four will be taken up with the germanium atoms and a surplus of electrons will be left. Germanium contaminated in this way is known as negatively charged N Type.

If however a trivalent atom—such as indium—is added, having only three valence electrons, we shall be one "light" in linkages or put another way we shall create holes in the structure and our contaminated germanium will now take on a positive characteristic—known as P Type.

Conduction is now possible because of the free electrons and because the holes can move. When an electron fills one hole it creates another and the holes will therefore travel in the opposite direction to the electrons.

In germanium consisting of both N and P components, a barrier will exist between them.

If an electron from the N germanium crosses into the P type through the barrier layer, the N type takes on a positive characteristic and if a hole traveling in the opposite direction joins the N type, then the P type becomes negative due to the loss of a hole. This

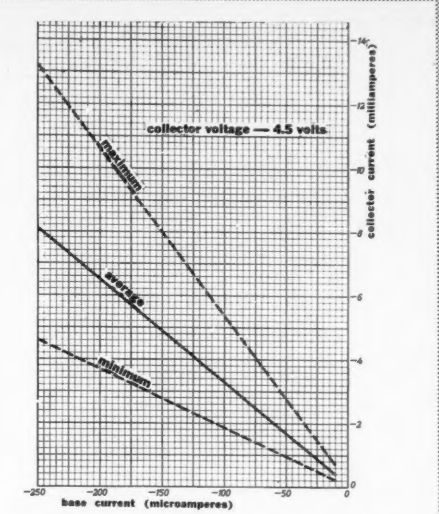
*Valence electrons are the ones which in chemical reaction are shared, gained or lost.

potential difference builds up and quickly stops further action, because the N type (being positive) will not attract further holes and the P type (being negative) will repel further electron invasion. This happens only when there is no external potential applied to the composite germanium, under which conditions it is a poor conductor.

When external potentials are applied, the situation changes. With a positive potential applied to the N germanium and a negative one to the P, both electrons and holes will be drawn away from the dividing barrier but as both electrons and holes cannot be supplied, a high resistance results.

With a reversal of polarity, that is, with the N type polarized negatively, then the electrons will move toward the P type and the holes toward the N type. Carriers exist and current flows and it has now taken on the familiar characteristics of a rectifier which, of course, is what it has become. So, we have arrived at a two electrode or diode device which, although having useful characteristics, has its limitations.

The graduation to the transistor or three electrode device is achieved by combinations of P and N contaminated types of germanium in the two sequences P-N-P and N-P-N. These have the general title of junction type. At first it seems that we have two rectifying



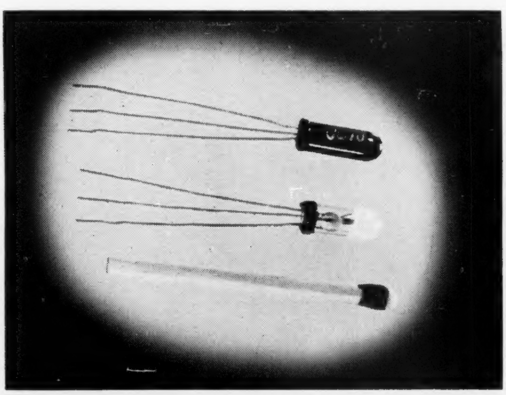
Germanium transistors vary slightly. Performance limits are charted here.

With the Latest Germanium Transistors

diodes back to back, but this is not quite the case because of the integral nature of the arrangement and the interaction between the activity to the left and to the right of the centre element (called base). This is the key to amplification by these devices.

In a P-N-P type germanium transistor we have an emitter, base and collector. In this case the emitter and collector are P type and the base is N type germanium. The base now becomes the point of reference and the left-hand P section is made positive in respect to the base and the right-hand P section is made negative in respect to the base.

Considering first the action which takes place between the base and the emitter when the emitter is positive, we see that there is an electron flow from the base to the emitter which is matched by a flow of holes in the opposite direction from the emitter.



The transistors are painted black to keep out light which affects current flow. Match shows small size.

However, this action is not isolated because the collector (positive in characteristic) is biased negatively and the holes from the emitter arrive in fact at the collector without combining with other electrons in the base. The emitter-base current flow directly influences the base-collector flow and even if the base-emitter current is stronger than the base-collector current, amplification still occurs due to the higher impedance of the base-collector barrier and the bigger potential difference.

It is interesting that the holes move from the emitter to the collector and combine with electrons in the base only to the extent of from 1 to 5%.

The purifying process that germanium has to be put through is unfortunate. It is costly and critical but, even so, semi-conductors are fast becoming a commercial reality. The transistor will take its place when industry is satisfied that it can be mass produced as easily as the vacuum tube.

A brief outline of the method of manufacture is interesting. The germanium is found in oxide form and is got as a by-product in zinc refining and, in England, by extraction from flue dust. The oxide is reduced to a metallic state by hydrogen and in the purification process the crystal is grown into a single state as distinct from the more usual multiple or mono-crystalline structure. It is during the forming of the mono-crystal that the impurities are added.

The germanium is usually in the form of a rod to which the additives are applied in layers—rather like a bread and meat sandwich—and in this way N-P-N layers with their barriers are produced. This composite rod is then sawn up for use.

It is quite apparent that there is room for improvement in the manufacture methods but it is encouraging that today usable transistors can be had and new versions are already on the way to industry.

Continued over page

Germanium Transitors *continued*

Already the transistor has made a really worthwhile contribution to hearing aid units because it has one-tenth the consumption and is only half the size.

Portable transmitters and receivers and many very small electronic brain devices are now being designed and it has already been shown to have good photo-electric properties. Photo-sensitive multi-electrode and power transistors are already on the scene, showing the trend for tomorrow.

Of course germanium is not the only semi-conductor which can be used. Silicon, for instance, has many attractive traits but it is difficult to process and when all the pros have been put against all the cons, germanium will usually be found ahead of its competitors.

The germanium transistor is very efficient because it has no heated cathode; it works on a low potential; it is small and robust; at present, it has a good life expectance and later it will have an even better one; and it is photo-sensitive. These are the pros.

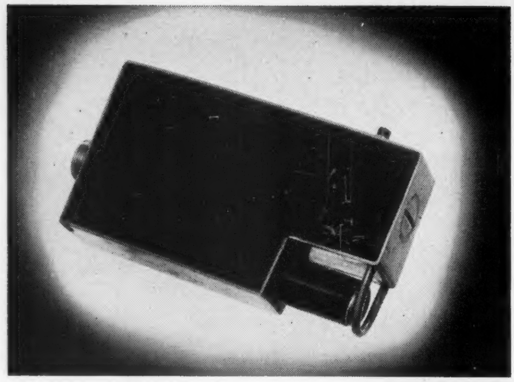
Among the cons should be listed that it is temperature conscious at about 50 deg. C in its present stage; it is noisier than the vacuum tube (this may not be so for long); and its frequency is limited due to transit time effects.

But when you subtract these from germanium's good qualities, you find it still sits high on the list of materials we are going to need in the electronic future.

Some idea of the part transistors will play in the electronics future comes from the new development of one capable of generating up to five amps to a motor. The power handling of this unit is made possible by a design which allows heat to flow quickly to the outside of the unit where it is easily conducted away.

Then there is the transistor fuel gauge — made of two elements. There is a combined indicator-amplifier on the instrument panel and a tank element in the fuel cell. Because transistors are small and need little power, this new gauge is smaller and lighter than more conventional models using electron tubes.

It is claimed that the transistor gauge has a long life and high resistance to shock and vibration; this means it need not be accessible and can, instead, he hermetically sealed behind the indicator.

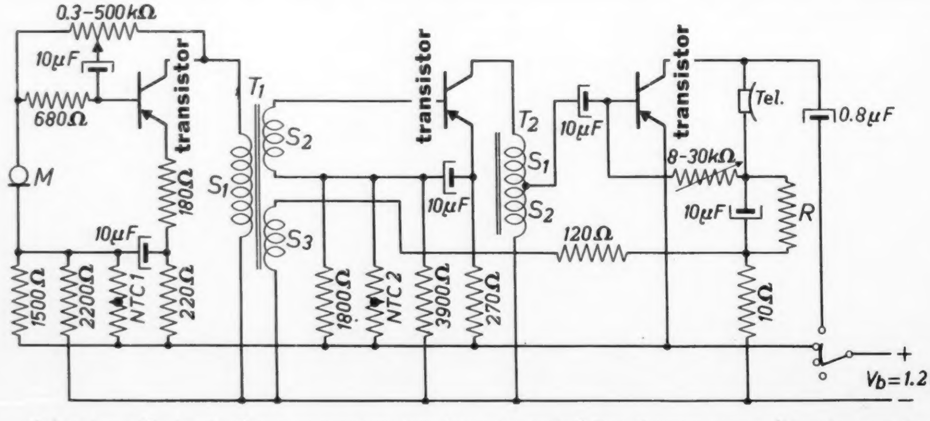


This new geiger counter uses germanium transistors. Its weight is 15 oz against usual five or six lb.

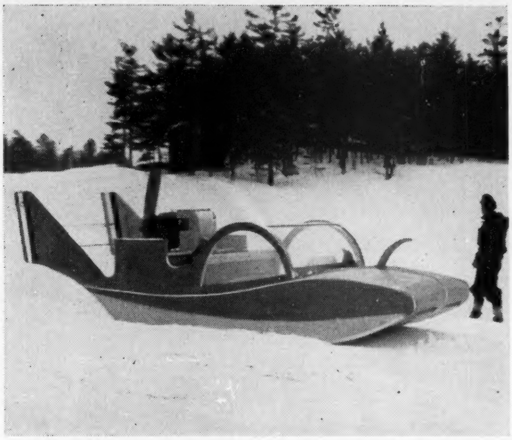
Who can say where future uses of germanium transistors will end? Certainly they will be used in communications — in dictating and other business machines, public address systems and high-fidelity radio. And they will be used for relays where compactness, durability and reliability are important. But this is just the beginning of the list. ★

Maximum limiting values

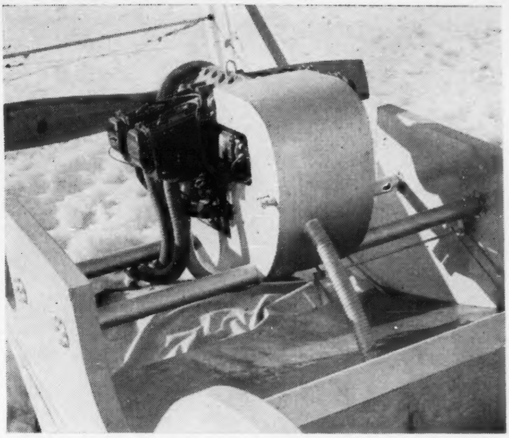
d-c collector voltage	V_c max.	4.5	Vdc
peak voltage	V_{cp} max.	10	V peak
d-c collector current	I_c max.	5	mAdc
peak value	I_{cp} max.	10	mA
d-c emitter current	I_e max.	5	mAdc
peak value	I_{ep} max.	10	mA
collector dissipation	W_c max.	6	mW
ambient temperature	t_{amb} max.	45	deg. C



A hearing aid circuit shows germanium transistors in typical low frequency amplification system.



The Mark II ice scoot is as fast as it looks here.



The aero engine is mounted only to the plywood sides.

This All-Canadian Scoot Hits 100 mph

This plywood prototype boat holds a motor suspended from the sides. It is quick, safe transportation.

AN ALL-CANADIAN powered ice scooter has been designed in Parry Sound, (Ont.) and is now racing through its proving tests. It was built by the Sound Boat Works.

The scoot is not a toy but a vehicle which can travel safely over snow, ice, water or slush at speeds of 50 to 100 mph. It does a job that no other vehicle can do.

The Scoot Mark II is an experimental model built to test the type of construction, the method of mounting the 115 hp Lycoming aero engine and propeller and the effectiveness of the twin air-rudders. Dimensions are: length over-all 17 ft, hull 12 ft, beam 5 ft and weight 750 lb.

The body has two box sides of ⅜ in. plywood, with spruce spacers fixed with glue and anchorfast nails. These sides are designed to take the thrust from the motor through the length of the hull. They are interconnected by a series of cross-braces and flexible bulkheads, covered with ⅜ in. plywood, to which is bonded light gauge galvanized iron.

The engine mount is of the simplest design. It consists of two 2½ in. diameter boiler tubes having flange plates on the ends for attachment to the hull sides. The engine is fastened to these tubes by two 3/16 in. mild steel web plates which means that it is suspended horizontally and not vertically, so that there is a clear air flow over, around and under the engine.

Although the cockpit is always open, it is free from draughts and a cigarette can be lit at 60 mph.

On one test run with three people up, Scoot Mark II traveled at 100 mph on a surface of snow-covered ice at a temperature of 10 deg F. In later tests under varying conditions it proved satisfactory and the motor mount showed no signs of giving trouble, even after bounding at speed over a 45-gallon oil drum to soar 10 ft before crash landing to a dead stop.

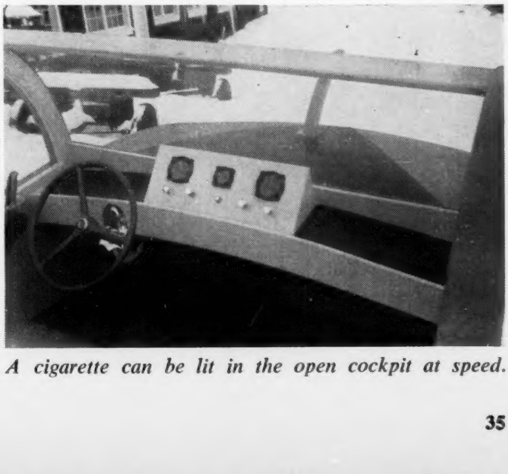
Gas consumption runs at 12 to 14 gallons an hour at a speed (on smooth ice) of about 90 mph. Designer Bob Sach (stepson of the world-famous boat designer Uffa Fox) believes that the Scoot has commercial possibilities and may go into production some day. It could be built for $2,000 without the engine; a reconditioned Lycoming would add no more than $600 to the price.

A follow-up design, the Mark II M, now going into production will build in several improvements—mostly to the steering, passenger positions and hull strength.

Seats will be moved further aft for a smoother ride and the new Scoot will have a higher freeboard to keep the propeller and engine clear of flying ice. Also, although the present hull is very strong structurally, armor plate will be taken up the full height of the sides to prevent pack-ice punching holes as it piles up.

One of the Scoot's most remarkable performance factors is its ability to race from ice to water and then back to ice without any change in the throttle setting; its speed over water is about 50 mph. It is light enough to frequently leave the ground at speed, "fly" 20 or 30 ft and land again unharmed. The designer hopes the Mark II M will be even lighter and faster.

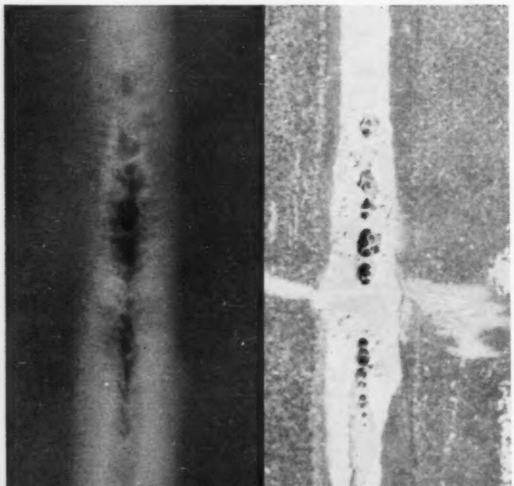
At least one (Toronto) manufacturer has shown interest in manufacturing the Scoot which seems to have an assured future. ★



A cigarette can be lit in the open cockpit at speed.

1. *The oldest use for radioisotopes. On the left the object on test, behind it a film, to the right an isotope.*

New Uses Are Being Found For Radioactive 'Agents' in Industry



2. *A defect revealed by isotope and film (left). On right, how the same defect looks by ordinary camera.*

Isotopes from atomic piles now cut radioactivity costs. So industry finds new uses for an oldish idea.

By Dr. P. J. Stewart
Isotope Products Ltd.

RADIOACTIVITY is news, but it is not new. Radium, which is naturally radioactive, has for years been used in radiography and for the treatment of cancer. And uranium, another active material, has won fame for its use in the atom bomb.

These natural radioactive materials are not easy to produce but luckily, artificial radioactive forms of cobalt, sodium, carbon and others — known as radio-isotopes — now come from atomic piles of the type used for the atomic bomb.

There are two types of radioactive radiation: beta rays, which make radar, radio, TV and other electronic equipment tick, and gamma rays, electromagnetic waves not unlike light rays and X-rays. They penetrate where light rays will not and are easier to work with

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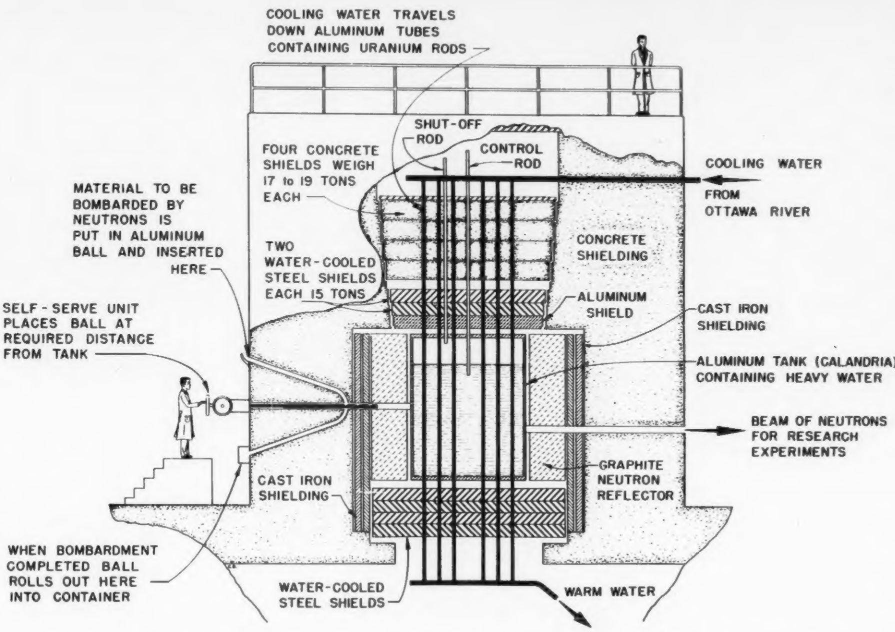


3. *A nuclear reactor is a sort of furnace and the more neutrons it has, the hotter it is.*

than X-rays. Two types of gauge are used with them; betameters, which apply beta rays to thin and not very dense materials: and gammagauges, which use gamma rays on thicker materials.

A radioisotope is a radioactive form of an element which differs only in weight and atomic structure from the element in its usual form. This change in structure is most important because it makes possible the release of useful energy.

Perhaps the oldest and best known use for radioisotopes is in metal inspection or radiography, as it is called. The isotope is placed on one side of the object to be inspected and a film, in a light-proof holder, on the other side (PICTURE 1). The rays pass through the object and register on the film, and any defects in the metal such as cracks or blow holes or bad welding show up (PICTURE 2).

Radium, the grandfather of all radioactive materials, has been used for this purpose almost since its discovery 50 years ago. Although still used to some extent, it is generally giving way to the newer, artificial radioisotopes.

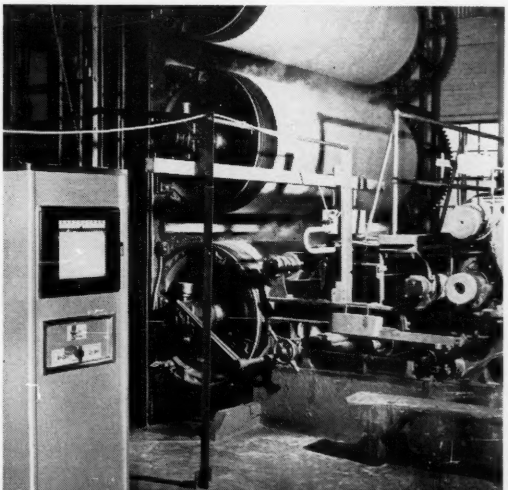
The technology of field radiography with iridium has been developed in Canada by Isotope Products Ltd., over the last four years, until now iridium is regarded as the ideal field radiographic material.

The gamma rays from iridium are actually among the least penetrating. Even so, they have an effective range for radiographic purposes of 3-in. steel and they are equivalent to the rays from some of the more powerful industrial X-ray units.

Cobalt 60, gives off even more penetrating gamma rays and gives good radiographs (PICTURE 2) in steel of 2 to 5 in. thickness. However, most structural welding and all platework falls in the ⅛-in. to 3-in. range, for which iridium always gives the best possible results.

Formerly, radioactive materials were accused of being too slow and of giving radiographs with too little contrast. The use of iridium has put both these faults right and has made much larger sources of radioactivity available. In the old days when radium

(Continued on page 62)



4. *Measuring the thickness of paper by betameter. Rays pass through the paper, radiation "stoppage" is watched.*

Auto Paints
Take Finishes to Highest Peak

By Dr. H. O. Farr
Canadian Pittsburgh Industries

The finishes science hits its highest peak in the auto industry. A car paint must protect from the weather and still add long life to beauty. Over 100 different blends have been produced to do so for Canada's auto factories.

THE BEAUTIFUL, light-fast, durable colors used to protect and sell the modern automobile have now taken the science of painting to its highest peak ever. No less than 100 different colors are used by the Canadian auto industry; in the U. S. this goes up to the astonishing figure of about 500.

Car makers in Canada buy over $3 million worth of paint products* each year—which is about 3% of all paint sales. A fabulous amount of care and cost goes into making these products the best they can be.

The research story began about 50,000 years ago. In the Palaeolithic age there were three colors—red, black and orange. They were made from earth pigments, charcoal and water by valiant prehistoric artists. The Egyptians took over in about 3,500 BC by discovering that potters' clay changed color during baking and that by grinding the clay with water, new colors could he had. Later, they added gums, eggs or waxes to the pigments to make much longer lasting paints. And of course the essentials of paint making are the same today—colors mixed with liquid binders. But the industrial revolution followed by huge production runs has made a science out of old art.

The automobile industry makes such heavy quality and service demands on paint makers that only a few are interested. In fact, out of 116 paint manufacturers, nearly all this market is handled by five companies.†

Yet competition for this automotive paint business is very intense, with each paint manufacturer trying to supply the highest quality, highest gloss, best application properties, and most economy. The automobile manufacturer not only must have a finish to protect the metal from exposure to the elements—sun, rain, dust, and road chemicals, but one which must serve as a package to help sell the product. The color and depth of the finish must have eye appeal so strong that it moves the customer into buying action.

And color can do exactly that. Color can create preference; color can attract attention, accent the best features of styling, identify the product and provide distinctive character. Car manufacturers are well aware of this and the industry has seen a quick revolution in car colors. For example: black, in the forties, accounted for 22% of all car sales. Today only 7% of new cars are painted black—a long hop from the famous remark accredited to Henry Ford: "You can have any color, providing it's black."

For the past four years light blue has been in first position, dark green has moved from eighth to second place, and green as a family of color (which has been glamorized through the use of polychromatic variations) leads the field by far. It is interesting that the automobile companies usually thought to be most aggressive in styling have always chosen aggressive colors to drive their leadership forward.

This year automobile manufacturers have gone all out for. more colors than ever before. Great accent is being placed on two-toned colors or even three color combinations on a single car, and pastel shades to appeal to the lady of the house are featured. But color trends seem to follow a repetitive cycle and it is possible that black and some of the darker colors may again be popular when the present vogue for pastels has run its course.

Sales of each color are watched carefully by automobile companies to help with forecasts for the future. The departments which do this look to color stylists from the various paint companies for guidance in choosing new shades. These color stylists are not long-haired artists, complete with palette, who daub paint on metal panels and stand back with appraising eye, to pronounce, "this will be the rage in '56!"

Instead they need a broad academic education in the art of color; they should have broad experience in the car industry from engineering to sales. They are in constant touch with stylists, interpreting and developing their ideas, creating and presenting colors singly and in series to help the stylists visualize new schemes. They should have a working knowledge of such products as plastics, rubber, fabric and hardware so that they can develop colors to complement the finished car.

Beyond all this, the color stylist must have a feeling for color trends and be able to foresee and appraise future changes. A casual remark overheard in the street that "everyone seems to have a light-colored car" may be enough to send the color man scurrying to his lab to work on a new series of darker colors. The stylist can never afford to be the drum major who turns a corner only to find that his band did not; on the other hand he is a pace-setter and once he is sure of himself, he must use everything he has to push his stylings into production.

Generally, the paint company's color stylist works two years ahead. He has to do this because all his

*Add to this the huge refinishing market. Body shops use about $5 million of paint products a year to repaint and touch up the nation's cars and trucks.

†Canadian Pittsburgh's Ditzler Division; Canadian Industries Ltd.; Sherwin-Williams; Glidden and Rinshed-Mason.

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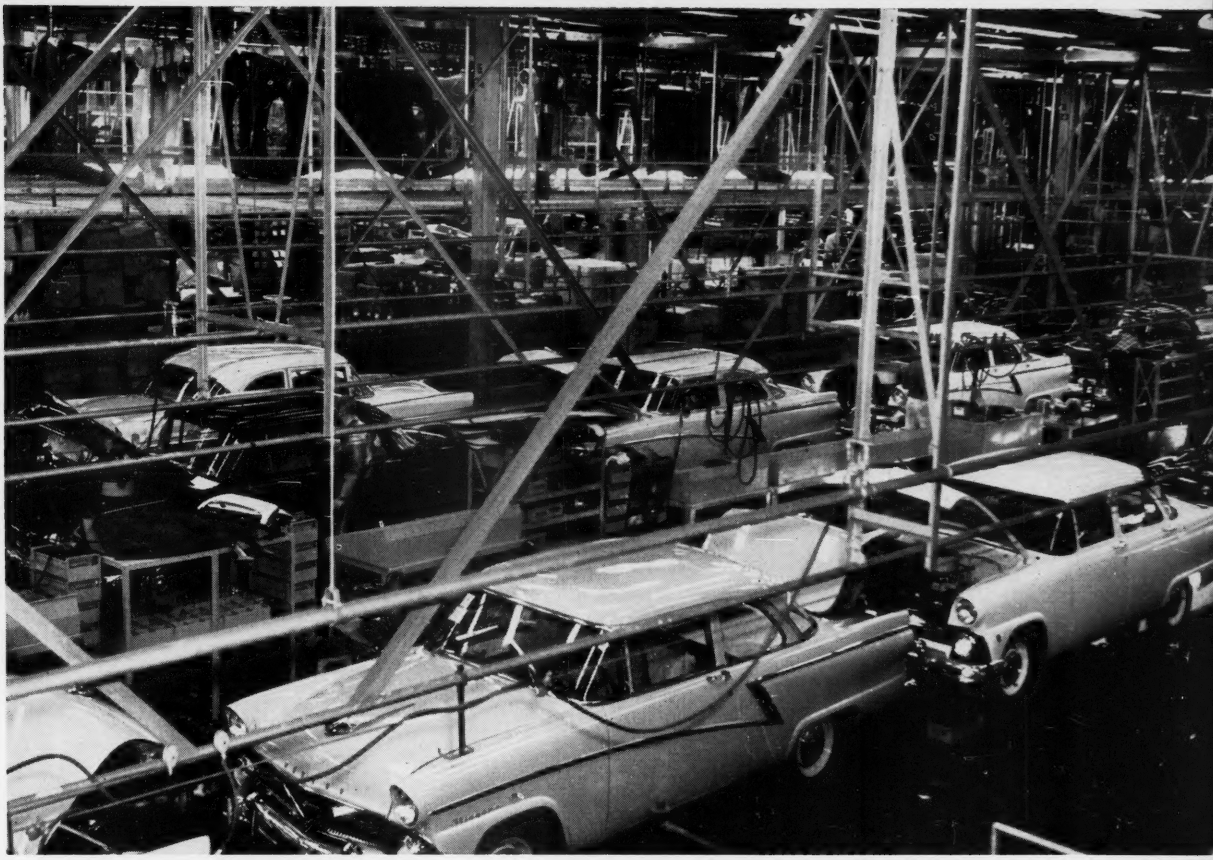
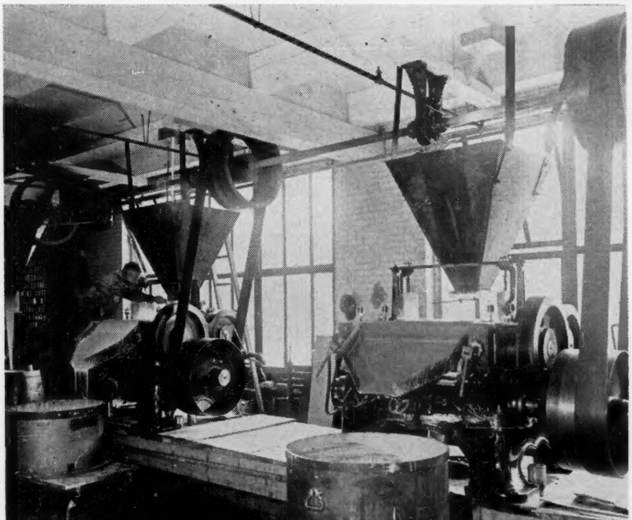
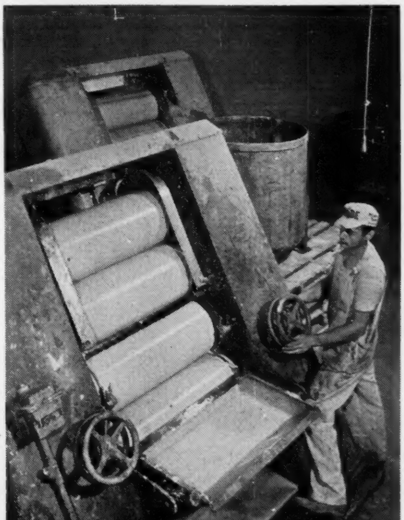


The final assembly line in a modern automobile factory. Here finishing touches to near-flawless finishes are given.

This year the car makers have gone for more colors than ever before.



A typical three roller pigment grinding machine of a few years ago. Paint fed downwards (which wasted space)—and production was slow.



Modern five roll mill like this gives improved quality, four times as much output.

colors must be proved before they go to the line. Well defined specifications of durability, workability, lustre, and ease of repair are imposed by car manufacturers and big paint companies insist, in any case, on their own rigid tests and specifications.

Nothing is left to chance. Ditzler colors, for instance, are all exposed to sea air, sand dust, sun and rain at the Pittsburgh Plate Glass paint exposure farm in Fort Lauderdale, Florida. Further exterior exposures are made at Windsor and Detroit. In addition they undergo severe chemical and physical tests during production. In fact, car paints reach the highest level of precision formulation, production, and control testing in paint manufacture.

Working within these limits the color man makes many presentations to the automotive industry throughout the year. In this way interest is maintained and he keeps his submissions in tune with the current thinking of the stylists. The color panels are best curved so that all shadows and highlights are picked up just as they will be with the final finish on the car.

If a particular color appeals to the automobile color stylist, it still may be rejected by the paint control department. It may be found to be unsuitable because infra-red rays cause a break-down in one of the pigments, or perhaps un-uniform color comes from a pigment which bleeds through to muddy the final result, or a dye used in manufacturing might be fugitive and fade away.

After passing all of the hurdles of laboratory testing and exterior exposure testing, the color finally selected must be mass-produced to match carefully the original color stylist's submission. If the cost is reasonable, and production line trials are good—this is one of the many colors you may choose from when buying a new car.

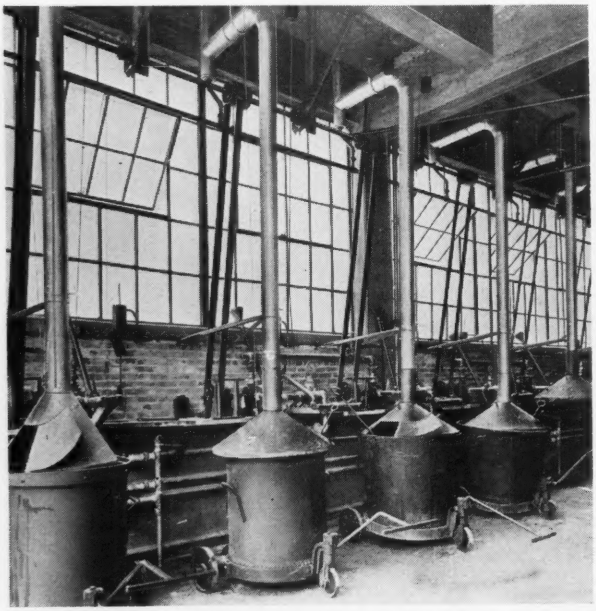
Actual manufacture of paint has not changed in principle very much from the early days. Pigments are ground by machine, not by hand, and modern mixing is done in huge steel tanks rather than in crude earthenware bowls with a wooden spatula. Of course technical control has become paramount in the fight for high quality and uniformity. But it is in the ingredients that the greatest changes have taken place.

Much progress has been made in the last 30 years in creating new light-fast pigments. The chemical industry, which sprang out of necessity from World War I, has added many synthetic organic and inorganic colors to go along with the natural earth colors. Synthetic iron oxides, brilliant reds from betanaphthol, phthalocyanine blues and greens, cadmiums and finely divided aluminum, just to mention a few, have added color, brilliance, and permanency to automobile finishes.

Perhaps even more progress has been made in binders for automotive paints. At first car finishes came from carriage enamels, formulated with slow drying varnishes which contained tung or linseed oil and copal or ester gum. In 1925 low cost solvents came along for nitrocellulose, lower viscosity types were developed and spray gun nitrocellulose lacquers reduced finishing work from several weeks to several hours.

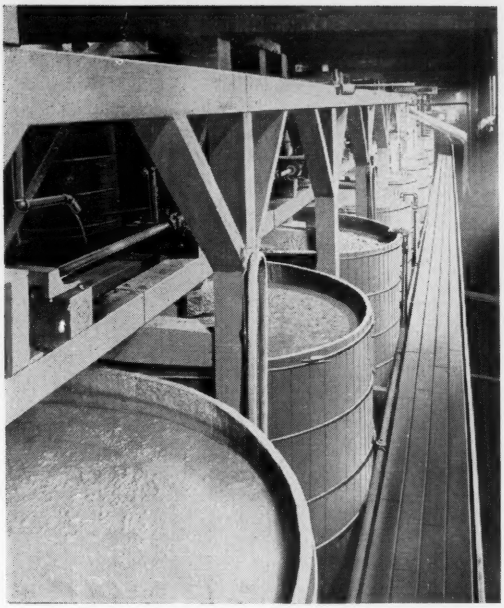
The late thirties saw the arrival of Glyptal or alkyd resins, which modified with vegetable oils became soluble in petroleum solvents. Gradual improvements have continued even today with this excellent and versatile synthetic paint binder, since thousands of modifications are possible from varied ingredients and cooking methods and through addition of other synthetic resins. This type of finish is used exclusively on Canadian production lines, although both lacquer and synthetic types are still used in the United States.

Paints made with glyptal and alkyd resins need a slightly longer baking time than other types. But they



Varnish kettles of days gone by. Thinners could only be added when varnish was hot. Modern alkyd type finishes like the . . .

. . . samples here have ended varnishing. There are over 100 long-life color choices in Canada.



Old fashioned wooden vats and overhead agitators are giving way to modern machinery and more automation.

Modern ball mill emptying into mix tank is part of paint industry's move toward fool-proof automation.

'Our automobile plants have the most modern equipment in the world.'

have proved more durable and to have a better hardness. They go through a special type of convection oven in the drying process; they are used exclusively in Canada because our automobile plants have the most modern equipment in the world.

Excellent durability, high gloss and depth of finish can be had from the lacquer type of automotive finish, but it has been largely replaced by alkyd types, and even where lacquers are still used on automobiles, they contain a high percentage of alkyd resins as film forming plasticizers for the nitrocellulose. The alkyd enamels today which enjoy most of the finishing market are usually modified with urea or melamine resins for greater mar resistance, toughness, gloss, and faster baking.

The chemical industry made alkyd resins possible by producing (from coal tar) naphthalene, which oxidizes to phthalic anhydride; and glycerine, a trihydroxy alcohol which comes from animal fat and can also be made synthetically. When phthalic anhydride is reacted with glycerine, a plastic mass insoluble in most chemicals results. But if the glycerine is first cooked with vegetable oils, such as linseed or soya oil, and then phthalic anhydride is added, a liquid resin polymer results which is soluble in petroleum or coal tar solvents. This resin keeps many of the properties of the vegetable oil (drying, flexibility, brushability) but also has some of the chemical and physical resistance of the glyceryl phthalate plastic mass. By making partial or complete substitution of the phthalic anhydride with other polybasic acids such as maleic, benzoic, succinic, or substituting other polyhydric alcohols such as pentaerythritol and glycols, for the glycerine, the binder can be very much changed. The oil content can be varied from 30% to 80% and many of the vegetable oils nature provides can be used.

Although all of the possibilities of alykd resin modifications have not been exhausted, alkyds are not necessarily going to reign for another twenty years. There are a great number of new types of binder on the horizon. Some are enjoying limited use, but a change in composition or a new technique in use may bring a new type of finish forward. With no intention of prophesying, but just to mention a few types of binder now enjoying limited use, the vinyl resins, the epons, the methacrylates, the silicones, the amine-aldehydes and the styrene resins bear watching. Sopolymers of many of the above are possible just as glyceryl phthalate and oil are now copolymerized.

The modern paint factory is notable for its lack of employees. Most processes take place in enclosed ball or pebble mills or in mixing tanks. Basically, the pigments are dispersed in paste form by being processed first in ball or pebble mills or on roller mills. Approximately 80 basic pastes of various colors are made up and carried as stock inventory.

These pastes are in turn mixed together in exacting amounts and thinned with resins until the correct color tone, hue, and value specified have been met.

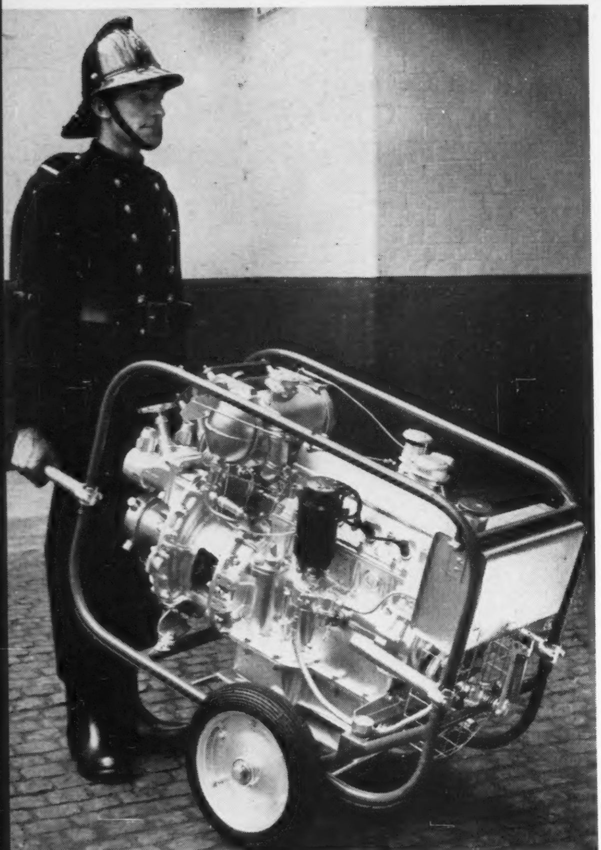
During the entire process of manufacturing the closest quality control checks are maintained. Precision formulation is the secret to good color matching and in a low profit business it becomes an extremely expensive operation if, after a batch has been made, it is found that due to negligence, proper color cannot be had with minimum tinting additions. As a result of this, employees should have good intelligence and pride in their work. It would be a fair statement to call them craftsmen.

Every physical precaution is taken to get rid of human error in production processes and as a further check, samples from all batches are sent to the laboratory where they are tested for color, viscosity, specific gravity, hardness, gloss, spraying properties, and bak-

(Continued on page 57)

Light Weight With Performance Was Achieved In this Fire Pump

Because this fire pump weighs only 310 lb. two men can carry it with ease. Yet it pumps about 20,000 gallons an hour through a bantam 33 hp motor. It is now winning widespread attention in Britain



1. *The new Godiva pump and motor can be wheeled over good ground like a wheel barrow, by one man.*

2. *On rough or obstructed ground, the entire unit can be carried by two men. Handles fold up when unwanted.*

THE GODIVA FIREPUMP weighs only 310 lb complete. Two men can carry it around on rubble littered ground with ease. Or, if the going is smooth enough to let it roll on wheels, a man can handle it alone indefinitely. Its dimensions are only 43 in. (length) by 19 in. (width) by 27 in. It can be trundled like a wheelbarrow (PICTURES 1 and 2). Yet it delivers 300 gallons of water a minute at a pressure of 100 psi.

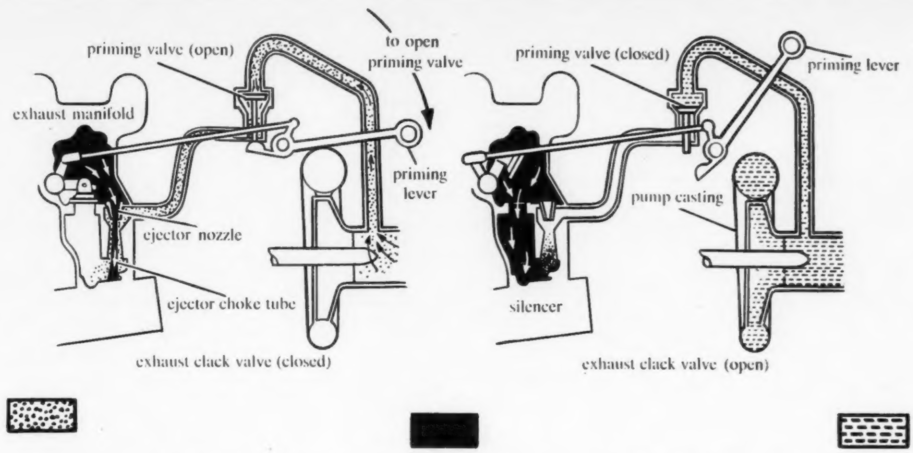
The recently designed pump comes from Britain's old-established Coventry Climax Engines Ltd., where it has won Home Office approval and is now going into use in many parts of the country.

The pump is a single stage, centrifugal type spigoted to the engine and driven through a flexible coupling. The volute body, which is split to give a smooth finish and to make cleaning easier, has a 4 in. round thread suction connection and twin outlets with 2½ in. delivery valves with instantaneous hose couplings.

As part of the struggle to keep weight down, an aluminum-magnesium-silicon alloy with high strength and good corrosion resistance was used for the pump castings.

Valve spindles are of stainless steel, for corrosion resistance, and the pump shaft, also of stainless steel, runs in ball bearings and is splined to the impeller.

Since the normal type of gland packing for the shaft seal was considered unsuitable due to its bulk, high friction and need for adjustment, a special mechanical face seal was developed. This automatically adjusts itself to take up wear. Friction is low because the sealing elements are of carbon and stainless iron and the whole seal unit is compact. Pressure areas are so designed that, no matter what the pressure conditions



3. *Dotted panel—air; black panel—exhaust gases; dash panel—water.*

in the pump, the pressure on the sealing face prevents leakage; at the same time it is not high enough to cause undue wear on the carbon sealing element.

An exhaust-gas-ejector priming system is used because of its lightness, efficiency and simplicity. The priming valve is integral with the volute body; a single operation of the priming lever opens the valve connecting pump suction to the priming gas-ejector and closes the exhaust clack valve, deflecting the gases through the exhaust ejector nozzle, (PICTURE 3). This means that air is extracted from the pump body and suction hose and a vacuum formed. When water reaches the inlet of the pump, the impeller develops a pressure in the volute which registers on the pressure gauge.

When the priming lever is released it allows the priming valve to close and the clack valve to open (PICTURE 3).

When the lever is released

Directly the priming lever is released, the water pipe from the pump to the intercooler is automatically opened so that cold water under pressure can flow through the intercooler coils in the header tank, and from there directly back to the suction eye of the pump (PICTURE 4).

This closed circuit system prevents water forming on the ground beneath the pump and so makes things better for the operator and others standing by the unit.

The system ensures a correct engine running temperature and stops overheating even when the pump is working for a long time at a stretch.

The system is completely automatic in action and allows anti-freeze to be used in the winter.

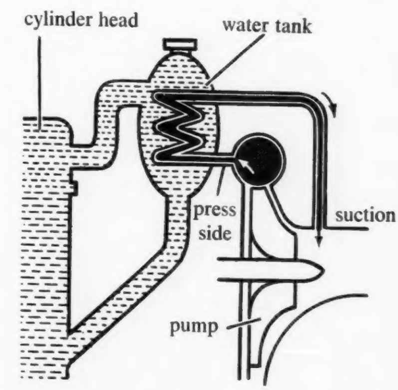
The frame is of mild steel tubing, welded throughout. It has four carrying handles, (PICTURES 1 and 2) which can be folded out of the way for easy storage. The whole engine-pump unit is mounted in the frame on four rubber cushions.

Since low weight was such an important part of the design aim, special efforts were made to keep the engine light without doing so at the loss of strength. The biggest single contribution to low weight came from the cylinder block and crankcase which were cast as one piece in heat treated aluminum alloy holding easily renewed slip-fit cylinder liners.

The engine is a four cylinder type and, although a bantam-weight, it develops 33 BHP at 3,500 rpm. It has a cast iron crankshaft of very robust design which is counterweighted and made with a large overlap between the crank pins and main journals. It is carried in three 2⅛ in. diameter by 1 in. wide bimetal bearings which are identical (and so interchangeable) and which need no scraping when fitting.

Connecting rods are steel and, so that they can be taken out upward through the cylinder bores, they are split diagonally. They rotate on renewable indium coated lead-bronze big-end bearings.

Pistons are aluminum and fitted with two compres-



4. *The intercooler system.*

Continued over page ▶

Light Weight Pump *continued*

sion rings and a scraper—all positioned above the wrist pin. Top rings are chromium plated which makes wear almost negligible. The pins are of high tensile steel push-fitted in the pistons and floated in the small-end bushes.

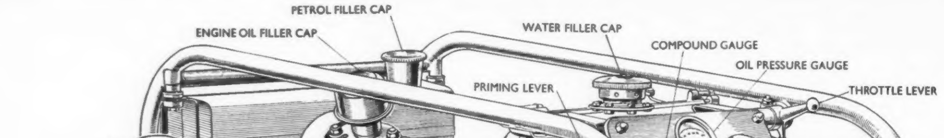
Valve design is interesting. The camshaft (of cast iron) is carried in three renewable bimetal bearings and moves the valves by direct action through chilled cast iron tappets which work in guides surmounting the valve springs. Tappet clearance is adjusted by means of hardened discs of graduated thickness. This layout gets rid of all side thrust and so gives the valve gear almost complete freedom from wear.

Another low-wear design feature is the slow piston speed of 1,315 (mean) ft per minute at 3,000 rpm. The lazy pistons are also said to give smoothness with high mechanical efficiency. The bore is 2¾ in., with a 2⅝ in stroke giving a compression ratio of 7.4 to 1.

A small (two gallon) gas tank will keep the motor working at full throttle for 1¼ hours while it pumps about 23,000 gallons of sea or fresh water.

Godiva firepumps are already in production for the British government's nation-wide civil defense scheme and for use by municipal fire authorities.

5. *A simple swing arm device holds the wheels to the chassis. Picture shows it in the release position.*



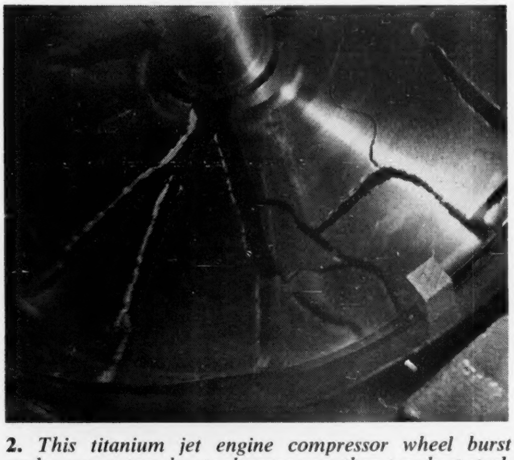
6. *A cut-away of the 33 hp light-weight Coventry Climax engine and pump.*

1. *A dramatic moment as swing grinders are used to scrape scale and other face defects from titanium ingots.*

What Do You Know About Titanium?

Costly manufacturing methods have kept titanium slow to develop. It is still little known by many engineers except as a name. Here are the latest facts about this important metal of tomorrow.

By W. L. Morse
Engineering Editor



2. *This titanium jet engine compressor wheel burst under severe test, but took more rpm than toughest steel.*

TITANIUM, A SILVER WHITE METAL, is widely distributed in the earth's crust. The ore is mined at Allard Lake, Quebec, and in India, U. S. A., Australia, Mexico, Norway and other parts of the world.

Briefly, the qualities that have made titanium and its alloys so promising are:

Density of titanium and its alloys is about 0.16 lb per cu in., a value intermediate between aluminum (0.10 lb per cu in.) and steel (0.283 lb per cu in.).

Strength of its alloys is greater than that of aluminum alloys and most steels.

Strength to weight-ratio. Better than for most engineering materials at both room and high temperature (in the range 300 to 1,000 deg F).

Young's modulus of unalloyed titanium is about 15.5 x 10^6 psi that is, intermediate between aluminum (10 x 10^6 psi) and steel (30 x 10^6 psi).

Corrosion resistance. Resistance of titanium to sea water and atmospheric corrosion is noteworthy. Platinum is, in fact, the only metal that excels it in this respect. The corrosion resistance of titanium alloys appears to be as good too.

Ductility. Excellent.

Fatigue strength is greater than for aluminum and higher even than for steel.

Hardness is greater than that of aluminum and approaches the high alloy steels.

Coefficient of expansion and **thermal conductivity** lower than for aluminum and alloy steels.

Impact resistance greater than aluminum.

Its disadvantages are:

Cost is high, top grade sponge being $4.50 per lb against 84c a pound for silver.

Continued over page

Creep. Pure titanium creeps and alloys so far developed show indifferent stress rupture and creep performance on long exposure to temperatures greater than 1,000 deg F.

This is well above the service range of aluminum and magnesium but below that of the high temperature alloy steels.

Rubbing properties. Titanium has cold welding tendency and so cannot be used for bearing surfaces without special treatment. However, several firms have developed anti-galling coatings for titanium which look very promising and, if they are successful in production parts, will bring titanium forward.

Titanium ore is first converted to titanium tetrachloride which, in the original Kroll process, was reduced to the metal titanium in an inert gas atmosphere, by the use of magnesium.

A more up-to-date method, with sodium instead of magnesium, is to be used by Imperial Chemical Industries in England and by the Electro Metallurgical Company at their $31 million plant in Ohio. It is rumored that there is also to be a similar plant at Welland, Ontario. It is claimed that this process gives a higher quality product.

This chemical reaction, is carried out at temperatures near 1,000 deg C, and from it comes a spongy mass of metal which must be separated from the other reaction products and melted into an ingot.

This melting of titanium is carried out under a vacuum or a blanket of inert gas, because titanium will react and burn to oxide if exposed to an air atmosphere while in the molten stage. Melting is done by the electric arc process using either consumable titanium electrodes or non-consumable carbon (graphite) electrodes.

Each method has advantages. The consumable electrodes are preferred to prevent carbon contamination. Their main disadvantage is the risk of a stop melt resulting in ingot discontinuity. However, recent carbon electrode techniques worked out by Rem-Cru show that it is possible to hold carbon below 0.20% by weight so that any carbon present is held in solid solution.

Melting is carried on in a copper crucible, water-cooled, and molten titanium at 3,020 deg F is contained in the copper cylinder without wetting it or burning through. Ingots weighing as much as 4,000 lb are being produced in this way.

The titanium ingots are converted to mill products in plants used also for the production of steel mill products. The same equipment is used for both metals in most cases.

But an entirely different approach to the problem, which it is hoped in time will lead to cheaper titanium, has been adopted by the Shawinigan Water & Power Co. of Montreal in their pilot plant for the production of high-grade titanium.

The process involves the electrolysis of a fused mixture of titanium chloride and one or more of the chlorides of sodium, potassium, calcium or magnesium; the titanium tetrachloride and the cathodic electrolysis products must be isolated from the atmosphere while this is done.

The titanium metal forms as a hard sponge, most of it sticking to the cathode.

Titanium production in commercial quantities began just after World War II, sponge production in 1954 being about 5,300 tons in the United States. Present plans forecast a production of about 35,000 tons per year in 1957. Experimental production is also being carried out in Canada, Great Britain, Japan and, no doubt, behind the Iron Curtain.

There are several types:

Titanium metal, in the so-called commercially pure form—about 99% titanium—exists in several different grades, depending on the impurities present in the material.

The grade most commonly used has a design tensile yield strength of 70,000 psi minimum. (This grade is covered by Aeronautical Material Specification numbers AMS 4901 and AMS 4921.) Other grades have design yield strengths of 55,000 and 35,000 psi minimum, but the latter is a high purity grade produced only in small quantities.

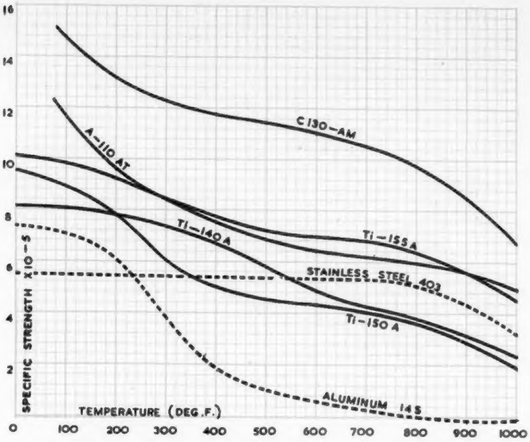
Commercially pure titanium (70,000 psi yield) has this performance: It melts at 1,725 deg. C.; its density is 0.163 lb per cu in.; its thermal expansion (from 20 to 700 deg C) is 9.5 x 10^{-6} per deg C; its electrical resistivity is 61 microhm—cm; its specific heat (from 0 to 538 deg C) is 0.13 calorie/gram; and its thermal conductivity (from 0 to 600 deg R) is 10.7 Btu/hr/sq ft/ft/deg F. These figures are based on work done for Rem-Cru by Battelle Memorial Institute.

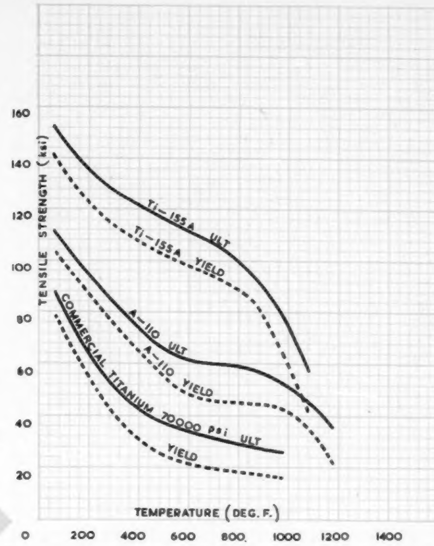
Details of the main titanium alloys are given in the Table. A few of these alloys are worth special mention.

Ti-155A is a high-strength forging alloy in limited experimental production, containing iron, chromium and

(Continued on page 68)

3. *Titanium's qualities make it valuable to jet engine designers. Here it is as a forged gas turbine blade.*





4. *Graph (above) gives strengths of titanium alloys and commercially pure titanium, at varied temperatures.*

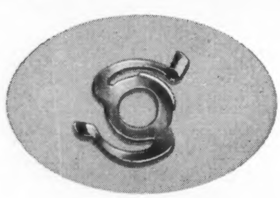
5. *The specific strength (strength to weight ratio) of titanium alloys, compared at different temperatures.*

Titanium production will hit 35,000 tons by 1957—and this is just the start.

		Minimum UTS ksi	Minimum Yield ksi	Minimum Elongation
REM-CRU A-55	Comercially pure titanium as annealed sheet, strip, forgings, plate, wire and tube	65	**55**	18
REM-CRU A70	Commercially pure sheet, strip plate, bar and wire	80	**70**	15
Ti-75A	Commercially pure as annealed sheet, strip and forgings	80	**70**	20
MST Grade III	**Low strength.** Commercially pure as annealed sheet, strip, forgings, plate and tubing	55	**60** (max)	20
	Medium low strength. Commercially pure as annealed sheet, strip, forgings, plate and tubing	65	**55**	20
	Medium high strength. Commercially pure as annealed sheet, strip, forgings and plate	70	**60**	18
	High strength. Commercially pure as annealed sheet, strip, forgings, plate	80	**70**	18
REM-CRU C-110 M MST-8% Mn	Binary alloy containing 8% manganese as sheet and plate	120	**110**	10
REM-CRU A-110 AT	Ternary alloy containing 5% aluminum and 2½% tin as bar, forgings, wire and sheet	120	**110**	10
Ti-140A	Medium strength alloy as annealed sheet, strip, bar and forging	130	**120**	12
Ti-150A	Alloy as annealed plate and forging	130	**120**	12
REM-CRU-130 AM MST 4Al-4Mn	Ternary alloy with 4% manganese and 4% aluminum as billet, bar and forgings	140	**130**	10
MST 6Al-4V	Aluminum vanadium alloy as annealed sheet, bar and forging	135	**125**	10
Ti-155A	High strength alloy as annealed bar and forging	145	**135**	12
MST 3Al-5Cr	Aluminum chromium alloy as annealed bar and forging	145	**135**	12

Q: How can you build greater reliability into your electrical spring parts?

A: With NORANDA PHOSPHOR BRONZE◆



Parts made from Noranda Phosphor Bronze (Alloys 35 and 36) retain their resiliency and high flexural strength year after year. The inherent characteristics of these rugged Noranda alloys also make them corrosion and wear resistant. And their excellent electrical properties increase the operating efficiency of parts.

For technical help in specifying the right alloy for electrical parts and prompt service on your metal needs, call your nearest Noranda Sales Office.

◆ One of the many Noranda Metals with High I.Q. (Inner Quality) for economical fabrication and improved products.

NORANDA COPPER AND BRASS LIMITED

Mills at Montreal East—Quebec, Canada

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Noranda is the Reliable Source for all Brass Mill Products

Patents

Some new ideas win protection in Canada

RADIO AERIALS made of glass plates are covered by Canadian Patent 510,172.

Conducting metal is deposited on the glass in strips to form circuits which may be given widely varying electrical characteristics. Deposits on both faces of the glass may be used to increase the variety of inductive or capacitive effects.

The patent issued to Manufactures de Glaces & Produits Chimiques de Saint-Gobain, Chauny & Cirey, of Paris, France: the inventor is Enzo Del Buttero of Milan.

• • •

OXYGEN BOOSTING for internal combustion engines, said to give power output increases up to 100%, was patented in Canada on February 15 by inventors Hans R. Fehling and Gerhard Friedlander of England: Patent No. 510,067.

Liquid oxygen is injected into the cylinder during or after the compression stroke, in addition to the normal charge of air. The air charge is cooled by heat exchange with the liquid oxygen, so increasing the weight of air that may be introduced: the normal fuel charge is then increased to give the added power desired.

• • •

AN IMPROVED plain bearing for use without lubrication has been covered by Canadian Patent No. 510,979.

The bearing surface is provided with dispersed pockets which are filled with a solid lubricant capable of forming a film on the surface of a rotating element. The outer surface is covered with a layer of poly-tetra-fluoroethylene which is retained in the surface pores. The pockets for the solid lubricant may be provided by a conventional style of indentator in a steel-backed bearing surface of sintered copper-tin.

Molybdenum disulphide is the preferred solid lubricant, but others such as graphite or camphor may be used.

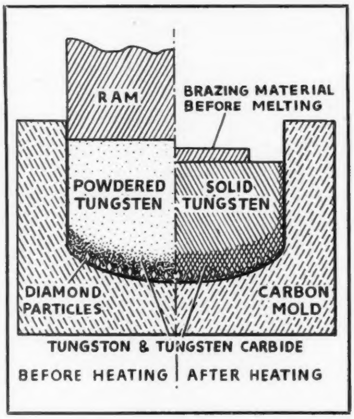
The inventor is Phil P. Love, of Wembley, England: the patent issued to The Glacier Metal Company, of Wembley, on March 15, 1955.

• • •

THIS DIAMOND ABRASIVE tool has exceptionally hard diamond-holding surfaces, according to Canadian Patent 510,250, issued February 15 to Wheel Trueing Tool Company, Detroit.

The drawing shows the tool in the mold assembly used in forming it. Diamond particles arranged in the carbon mold are covered with a mixture of powdered tungsten and tungsten carbide. Above this is a layer of tungsten powder. The assembly is compressed with the ram, and the block of brazing material is placed on top as shown in the second figure. The compacted mass is preheated to cause the carbon of the mold to combine with the tungsten powder, producing an extremely hard surface layer for holding the diamonds.

Further heating at higher temperatures



melts the brazing material; this provides a bond for attachment to a tool shank.

The Vickers hardness of the carbide outer surface is said to be as high as 2600. Inventor: Leo Catallo of Detroit.

• • •

NORTHROP AIRCRAFT, INC. has obtained Canadian Patent 510,192 on the manometric accelerometer shown. It is said to give readings that are more linear than those of known instruments of the type.

The accelerometer has two chambers for liquid connected at top and bottom by conduits. The chambers hold an electrolyte, and each chamber has two electrodes projecting from the insulating body into the electrolyte. Magnesium nitrate in ethanol is good electrolyte.

The electrodes are connected to a suitable bridge circuit which produces a signal depending on the respective levels of the electrolyte in the two chambers. The signal is indicated on a suitable instrument in the circuit.

Acceleration or deceleration or angle of tilt causes flow of electrolyte through the lower conduit, thus altering the levels of electrolyte in the chambers; this changes the resistance in the two arms of the bridge circuit and the degree of change is indicated on the instrument in terms of velocity change or tilt.

The patent issued February 15: the inventor is Robert E. Bareford of Burbank, California.

• • •

A MOLDABLE QUICK SETTING compound which can be used to form a temporary jig for holding metal parts is covered by Canadian Patent 510,706, which was issued on March 8 to Eutectic Welding Alloys Corporation of New York.

These are the ingredients claimed: asbestos—50%; sodium silicate—25%; sodium carbonate—12.5%; glycerine—6.25%; and ferric oxide—6.25%.

The inventor: Rene D. Wasserman.

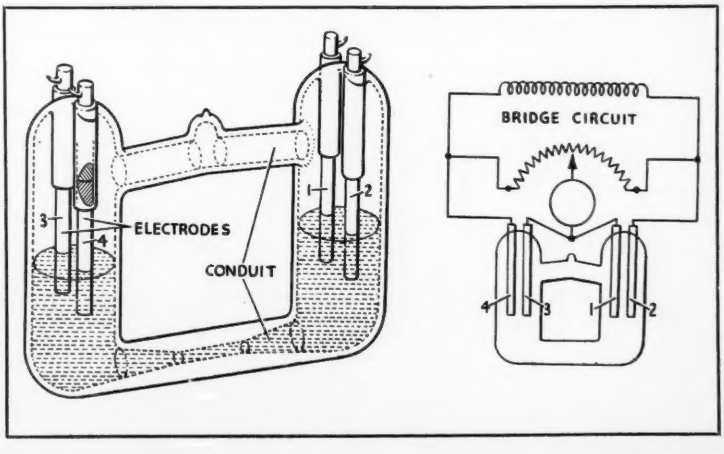
• • •

PITTSBURG PLATE Glass Company has patented a method of making a transparent electroconductive coating on glass.

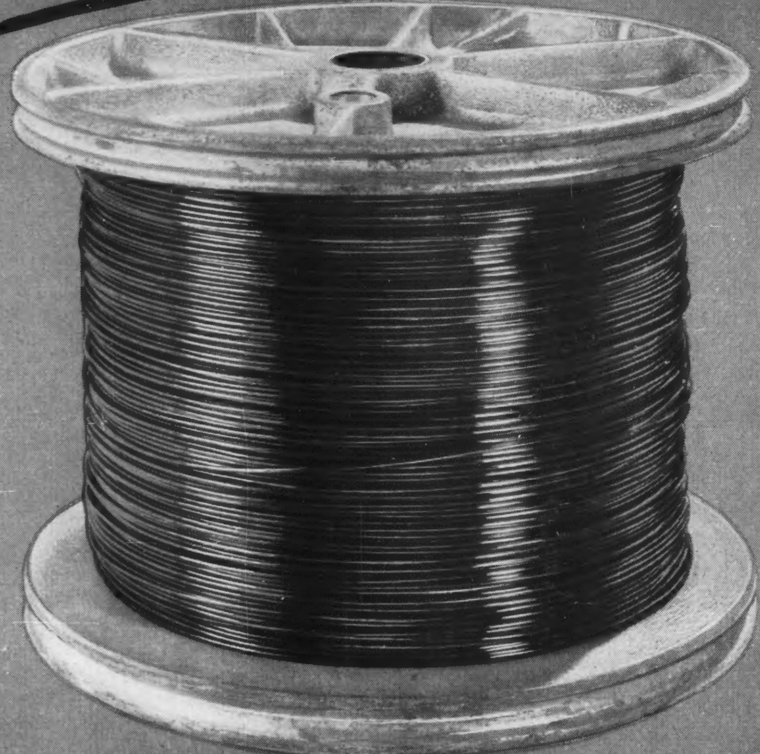
According to the patent, lime-soda glass is heated to above 500°F and contacted first with hydrofluosilic acid and then with a tin compound, which decomposes to deposit a transparent coating of tin oxide.

The glass base is said to remain substantially haze-free despite the coating operation.

Patent No. 510,787, March 8; inventor: Albert E. Junge of Pittsburg.



Announcing



HEAT STABILITY

Heated for 100 hours at 185° C, Alkanex can be elongated 16 to 20 inches per minute by at least 25% or to the breaking point of copper without cracking or tubing the Polyester-Film insulation.

PHYSICALLY

The new Polyester-Film insulation on Alkanex offers greater adhesion, superior mechanical strength, chemical resistance and abrasion resistance.

ELECTRICALLY

Alkanex is equivalent to Formex. At elevated temperatures, however, twisted pairs, treated with a compatible varnish system, are superior to similarly treated pairs of Formex wire.

Vibrations

(Continued from page 27)

ω is squared and multiplied by each of the values under column 2 to give column 3. Under column 4, No. 1 mass is given unit twist ($\Theta = 1.0000$). Columns 3 and 4 are multiplied to produce column 5, which is the increment of vibration torque. The first line under column 6 is naturally the same as column 5. Column 6, divided by column 7, gives column 8, the increment of twist $d\Theta$ in the first section.

This value of $d\Theta$ is subtracted from $\Theta = 1.0$ in column 4 to give the amplitude at mass No. 2. Columns 3 and 4, line 2 are then multiplied to give the increment of torque, which is set down in column 5, line 2. Line 2 of column 5 is then added to line 1 of column 6 to make up the torque summation in step 2 shafting and this value is set down in line 2 column 6.

Again, $\Sigma J\omega^2\Theta$ is divided by the C value on the same line to give $d\Theta$. This sequence is repeated, line by line, until toward the bottom of a first frequency tabulation, the values of Θ become negative. This makes $J\omega^2\Theta$ values negative, so that as they are added to column 6, the absolute value of $\Sigma J\omega^2\Theta$ gets less. When the last line, column 6, becomes zero, we know that our estimate of the frequency is exactly right. If it is far removed from zero, another estimate must be made and the tabulation repeated. When the residual $\Sigma J\omega^2\Theta$ becomes very small in relation to the other values in the table, our estimate is sufficiently close for all practical purposes.

Column 4 tells at a glance the mode of vibration we are solving. If Θ changes from positive to negative, it is the first frequency (one-node mode). If it changes from positive to negative and back to positive again, it is the second frequency (two-node mode).

After finding the value of the natural frequencies, (1st, 2nd, 3rd and so on) as necessary, depending upon the importance of the orders falling within the running range, the next step is to calculate the relative amplitudes (twist). When using the Holzer table, the relative amplitudes are found simply by referring to column 4.

The torque per radian of free and amplitude—near No. 1 cylinder—by the Holzer method is found for each step of shafting directly in column 6.

Since $T = \frac{\pi}{16} f D^3$, the stress per degree of amplitude is found for any or all sections of the shaft by taking the appropriate torque value from column 6 and dividing it by $11.25\ D^3$ where D is the shaft diameter in inches. Or, for a hollow shaft $11.25 \frac{(D^4 - d^4)}{D}$ where D and d are the outside and inside diameters of the shaft respectively. It is usually possible to tell, by glancing at the torque values, which of the shaft stresses will govern. Where more than one diameter is involved in any particular section, it is obviously necessary to use the minimum diameter in the stress calculation.

Stated briefly, the balance of the problem consists of finding the equilibrium amplitude for the various orders, multiplying the equilibrium amplitude in each case by the stress per degree to obtain the equilibrium stress, and multiplying the equilibrium stress in each case by the dynamic magnifier at resonance to find the peak stress at resonance for each order.

Equilibrium amplitude, as the name implies, is the amplitude which would exist at any point in the system for any of the several modes of vibration, if the magnification due to resonance with the external pulsating torque were removed.

When dealing with systems with six or seven masses, it is better to use the Reduction Method developed by F. P. Porter. By this method, frequencies can be found with extreme accuracy after filling out only two or three lines of a table. The table is of such a form that a different frequency value comes out at the end from the one which was assumed at the beginning. The new value is used in the second line and it usually turns out to be uncannily correct, as shown by its reappearance at the end of the second line. If a slightly different value should appear, there is a formula for averaging the three values and it is a practical certainty that this fourth value will be extremely accurate.

The setting up of the tables for using the Reduction Method is something of a specialized art.

Here is a very brief outline of the steps to be taken for working by the Reduction Method after solving for the natural frequencies.

1 Work out the relative amplitudes at each mass assuming unit amplitude at one end (called the beginning).

2 Using the relative amplitudes, work out the relative moments in each section of shaft per degree amplitude at the beginning.

3 Using the relative moments, calculate the relative stresses in each section of shaft per degree amplitude at the beginning.

4 Compute the energy input to the order of vibration in terms of the harmonic component of the tangential effort and the vector summation for the respective orders per degree amplitude at the beginning.

5 Compute the energy dissipated in damping per degree amplitude at the beginning.

6 Equating energy of excitation to energy dissipated in damping, calculate the actual amplitude at the beginning for each critical speed.

7 Multiply this amplitude by the relative stresses per degree in each section to find actual stresses in each section of the shaft.

Much of the empirical data on damping and stiffness factors is obtained by using an instrument known as a torsiograph and it is this same torsiograph which enables us to confirm and strengthen calculations which are now

(Continued on page 57)

A Pioneer's Fence

FIFTY YEARS AGO, no one who owned a patent in the automobile field could use it without a license from George Selden.

Selden took out U. S. Patent 549,160 for a "Road-engine" in 1895. If it were still in force today, it would cover every automobile on the road.

A patent is like a fence to protect your land from trespassers. Selden's was like the fence around a large estate—it covered a lot of territory. But most patents are narrower and protect less territory—like the fence around a city lot. Sometimes the territory covered by a narrow patent is right inside the area covered by a broad one. It's like a fence around a small farm with the fenced-in land of a big landowner all around it.

The big fence stops the owner of the small farm from reaching his own property unless he gets a "right of access"—in the form of a license—which enables him to pass through the big fence. And of course, the little fence keeps the big landowner off the small farm. In 1912 the Selden's "big fence" was torn down; the patent had reached the end of its seventeen-year term.

There are still many dominating patents like Selden's. Sometimes they are called "pioneer patents." These are the promised land for every research and development staff. (Contributed by Roy V. Jackson.)

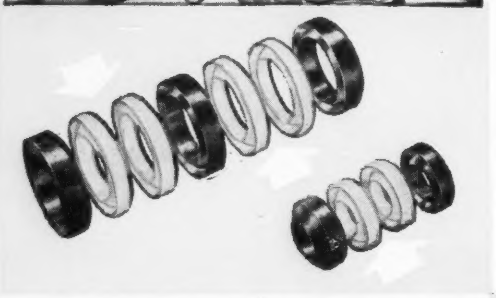

Spring
WE FILTER OUT THE IRRITANTS
OBLEMS

If you have a Problem

calling for a tough, light, flexible corrosion resistant material...

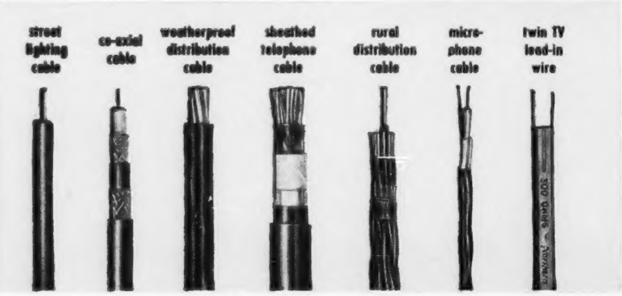
consider polythene

—it can be easily moulded and extruded—is now used for flexible pipe, gland packings, spring liners, battery components, wire and cable insulation and dozens of other applications... polythene is non-toxic, has exceptional dielectric properties, remains flexible and strong even at sub-zero temperatures.



These polythene chevron ring packings (for 1¼" check valve and 2" shut-off valve) have been an outstanding success under high pressure and wear conditions. They have a resistance to "work hardening" which is a major problem in the conventional type of sealing ring.

Polythene's excellent electrical insulation properties and moisture barrier qualities make it ideal for insulating many kinds of wire and cable. The illustration at the right points out the wide extent to which polythene is used in this range of Northern Electric wires and cables.



Look for new products, new developments in the pages of the C-I-L "Plastics Sphere"

C-I-L

SERVING CANADIANS THROUGH CHEMISTRY

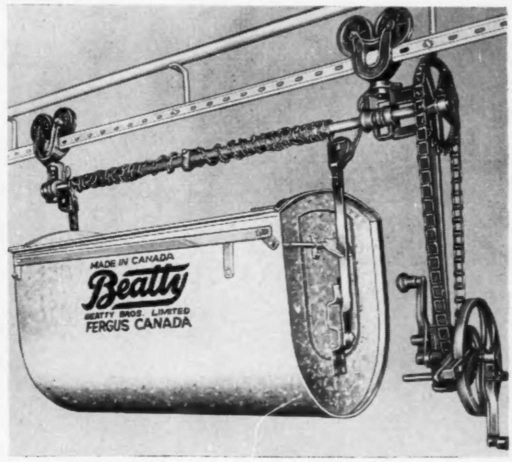
plastics

SUPPLIERS OF PLASTIC RAW MATERIALS

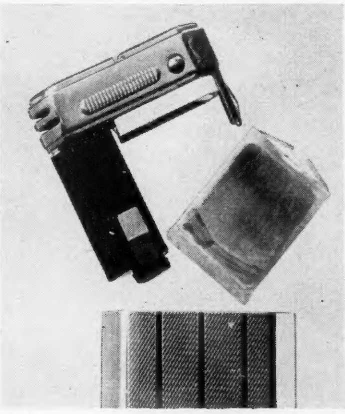
Design news in pictures

Some modern designs making news today

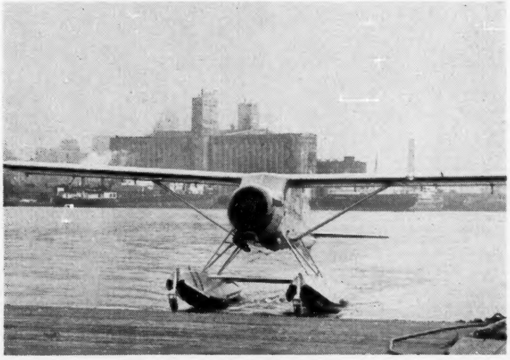
An Italian look comes to the new Nash Statesman. Head lights have moved in. Small parking lights show width.

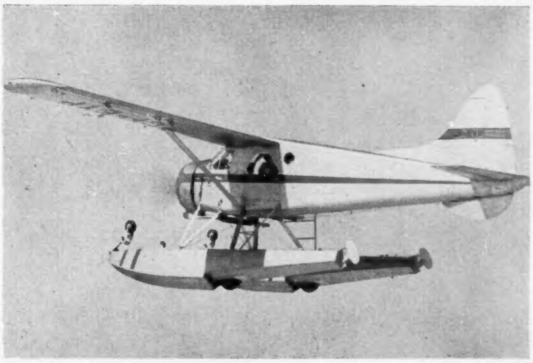


A new manure carrier by Beatty Bros. runs by gravity takes only 11 lb. pressure on handles to raise loaded.



A new Ronson electric shaver with pliable steel head comes packed in real calf-skin. Centre, the **Fumalux** lighter which has a battery, no flint is on sale in Canada. Right, RCA's first-ever **electronic cooler.**





De Havilland Aircraft of Canada has completed flight testing the new Amphibious Beaver; it uses standard floats and wheels suspended below the floats which retract into the float-wells when the Beaver is used as a seaplane.

Plan your future products with

BAKELITE Polyethylene for

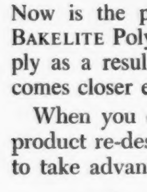
TRADE-MARK

better performance, economy, sales appeal

Now is the practical time to start planning with BAKELITE Polyethylene. The future—increased supply as a result of planned production expansion—comes closer every day in Canada.

When you consider this material in the light of product re-design, you will find a great many ways to take advantage of BAKELITE Polyethylene's unusual combination of advantageous properties.

You may be able to apply its impact strength, dielectric properties and ease of fabrication to critical design problems...or determine how its light weight, flexibility and corrosion resistance can give your new products-to-be an edge in performance, saleability, and manufacturing cost reduction.



The many properties, plus examples of uses, are shown in our 24-page booklet, BAKELITE *Polyethylene*. Write for your free copy **today.**

BAKELITE

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Polyethylene

BAKELITE COMPANY, *A Division of Union Carbide Canada Limited* UCC Belleville, Ontario.

Sales Headquarters: Toronto, Ont.—Sales Office: Montreal, Que.

Vibrations

(Continued from page 52)

being made for new installations. Various types of torsiograph have been developed, some of which are quite complex and indirect in their approach. A very direct type (PICTURES 1, 2) makes use of a seismic mass, spring mounted to oscillate coaxially with a pulley, which is belt driven by the machine under test. The torsional oscillations of the shaft under test are transmitted by an inelastic belt to the instrument pulley and the relative angular displacement between the pulley and the seismic mass is translated into linear motion. This is magnified in a stylus which records the vibration on a traveling strip of waxed paper. Two markers also make inscriptions, one every second and the other every ten revolutions of the pulley. By studying the record produced, the engine speed, the order number and frequency of the vibration and the amplitude of vibration at the point of take-off are readily deduced. These values can be compared directly with calculated values.

It is, of course, necessary to make a careful search throughout the running range, at small increments of speed variation, to find the exact speed at which a peak amplitude occurs for any particular order of vibration. The order number is found by dividing the travel of the paper during one engine revolution by the wave length of the vibration. This order number, multiplied by the engine speed at the time of maximum amplitude, gives the natural frequency for one of the modes of vibration. The amplitude, translated into degrees at the take-off point, and multiplied by the relative stress per degree amplitude at that point, will give the actual vibration stress at any point in the system.

Look at the record

Picture 4 shows the torsiograph record of a ninth order vibration. The interval between markers at the top tells the chart travel during one second of time, in this case 1.89 in. The lower markers indicate the chart travel during the time taken for the instrument pulley to make 10 revolutions, in this case 2.03 in. Knowing this, and the ratio of the engine shaft diameter to the instrument pulley diameter, it is easy to calculate the engine speed (293 rpm in this example). Also the length of chart corresponding to one engine revolution can be found being 0.386 in. The number of complete vibrations in the space of 0.386 in. is counted and this is called the order number of the vibration. There are nine vibrations per revolution on this record, so that this vibration, as has already been mentioned, is of the ninth order.

The frequency of the vibration is then found by multiplying the order number by the engine speed so that here, the frequency is $9 \times 293 = 2{,}637$ cycles per minute. The angular displacement in the shaft at the take-off point is proportional to the height of the wave of the record. So half the wave height divided by the magnification in use multiplied by the conversion factor for the instrument $\frac{1}{0.034}$ multiplied by the ratio of pulley diameters is equal to the angular displacement in the shaft either side of the mean position (plus or minus). Since the shaft stress per degree is known from the torsional vibration calculations based on the mass elastic system, it is then necessary to multiply by the actual displacement to arrive at the actual stress.

In choosing the take-off points for the torsiograph drive, it is best to examine the shape of the normal elastic curve (relative amplitude). The free end of the engine is usually the best place to find readable amplitudes for all important modes. If a drive is taken near a node or at any point of weak vibration and the attempt is made to magnify the record to a high degree, the measure of the amplitude is apt to be misleading, particularly at higher frequencies. Belts should be as short as possible, magnifications low and mountings arranged so that pulley centre distances are constant.

Look at the diesel generating set

(Continued on page 71)

Auto finishes

(Continued from page 41)

ing. Paint, when it is on the production line, must be workable.

On the line there can be no mistakes —a $3,000 to $5,000 piece of merchandise is nearing completion and much depends on this new product being wrapped in an attractive (but still durable) color package to excite the buyer and close the sale.

Look inside a modern automobile production line at the steps involved in painting. First, all grease, oil, and other surface stains must be removed before the body is ready for paint. Generally this is done by cleaning it with an alkali, passing it through a hot water rinse and then spraying with a phosphate solution. After phosphating, the body goes through another water rinse, then into a chromic acid solution spray. This weak chromic acid acts as a sealer and protects the phosphate coating until the body surface is sprayed with paint. During this process 4,000 gallons of solutions and water are sprayed on the body, just to make sure of a chemically clean surface.

After the acid wash, the primer surface is sprayed on the body. Then the body goes into a bake oven at 275 deg. to 300 deg. F for about 28 minutes. After a thorough baking, the body is carefully water-sanded down, washed, blown dry, and rolled into a dry-off oven at 275 deg. F. A first spray coat of enamel is the put on the body and door jambs, inside of deck and deck lids. The body is dragged once again through a bake oven for 20 to 30 minutes at 265 deg. to 280 deg. F.

Each body is mounted on a dolly (or suspended from a monorail) which is moved along by a conveyor operating at about 20 ft. per minute. The dollies operate switches that turn the automatic paint spray guns on and off so that the several guns only operate while the bodies are in the spraying zone. The guns operate at 12 to 18 lb. nozzle pressure and 70 lb. line pressure, and each sprays about 1 pint a minute.

After another inspection the cars are spot-sprayed by hand (if necessary) and the uppers of two-tone orders are sprayed. Again the body moves into a bake oven —this time for 20 minutes at 250 deg.

The tops of two-tones are masked off and the lower bodies receive final sanding, clean-up and blow-off. They pass into a dry-off oven and get their final finish coat of enamel. The first coat is given all over. A second all-over spray coat is added except for two-tones. About three minutes are allowed between coats and five before the cars enter the bake oven for the final time. Temperature is 250 deg. to 265 deg. F and time is 28 minutes. The bodies then travel to the final assembly line where they meet their component parts which have undergone a similar type of paint treatment.

After the cars are assembled and inspected, if any paint flaws are found, these are spot-sanded, spot-sprayed, and baked in the repair oven. The first three minutes are under infra-red lights to bring the temperature up quickly, then 20 minutes in heated air at 185 deg. F and, lastly, a three minute cool-off period. The total amount of paint used on a car is about 3½ gallons, excluding undercoatings and engine paints. The final thickness of the paint job is roughly 2¾ to 3 mils.

As design and mechanical engineers go ahead with improved features and performance for tomorrow's automobile, there is little doubt the finishes men will keep with them. New finishes with even better durability and beauty are coming; paint technology will not lag behind. ★

Quotes

Points from current papers and speeches

AT A RECENT ASTE lecture, **Dr. Irvin R. Kramer,** under the heading "Investment Castings by the Frozen Mercury Process," stated that for parts in new metals such as the high-nickel and high-chromium alloys, the cobalt-base alloys and other metals used in gas turbine and similar equipment, there are conditions which cannot be easily met by conventional production methods.

While sand casting, forging and machining methods are used successfully to make many parts from these new alloys, they can be produced more economically by the investment casting method.

The advantages of using frozen mercury as a pattern material result from two fundamental physical properties of mercury: **1** the low volumetric change on melting; and **2** the high rate of self-diffusion which allows solid mercury to be self-welding.

The small volume change which occurs during the melting allows large parts to be made and the use of a thin shell mold, which is an advantage itself.

In principle, the frozen mercury process is simple. Liquid mercury is poured into a steel die and frozen in an acetone-dry ice-bath, which is maintained at minus 100 deg. F. During the freezing period, the die is progressively lowered into the bath to control the solidification so that the surface is free from shrinkage defects. The surface of the frozen mercury pattern is very smooth and clean, and free from imperfections. Because of the high density of mercury and the general properties inherent in a liquid, no difficulties are encountered in filling thin sections or sections which vary greatly in cross section.

The maximum benefits which can be derived from the use of the frozen mercury process start at the design stage of a casting. Usually when a part is designed, the designer will have in mind some method for the manufacture of the part. So the part is limited by his knowledge of processing methods.

By its ability to produce complex shapes, the frozen mercury method gives the designer much more freedom to design parts from a completely functional point of view, unhampered by manufacturing problems.

Research at the Knolls Atomic Power Laboratory, and other laboratories, has shown that nuclear radiations can discolor many materials, render certain plastics tougher while reducing others to powder, change some liquids into solids and take the stretch out of rubber.

• • •

A PAPER given by **Dr. Samuel S. Jones,** a General Electric Company scientist at KAPL, told the Society of the Plastics Industry of Canada, about effects of nuclear radiations on organic materials. He said that such radiations bring about operation problems around nuclear reactors, but offer opportunities for valuable new processing methods.

He explained that near reactors the possibility that radiation can harden or powder certain types of electrical insulating materials, decompose paint and melt down certain rubbers, posed many technical worries.

At the same time, he said, many plastic materials and dyes change color under irradiation. Oils and other lubricants are thickened. Certain liquid polymers are made into solids, while other solid polymers are reduced to semi-liquids. Dr. Jones said that in spite of this, nuclear radiation offered hope for new and improved processing methods. He pointed out that nuclear radiation can sterilize foods and drugs, toughen certain types of plastics, produce insulating material by degrading certain plastics, and perform other chemical transformations.

However, he pointed out that radiation will be most useful where it can be employed in small amounts for unusual results. Radiation applications already being tested are, for the most part, those where other methods used to give the same effect are difficult or impossible, the GE scientists said.

Plastics, broken down into smaller molecules by radiation, also may provide products of some practical value.

It is reasonable to expect that pile radiations, with their advantage in penetration, will receive more attention as more and more nuclear reactors go to work. However, in some cases reactor irradiation will have the disadvantage of producing undesirable radioactivities.

• • •

IN A PAPER delivered by **L. F. Bogart,** in the use of plastic as a tooling material, he stated that during World War II the aircraft industry turned to plastic materials to find a substitute for the then scarce metal materials. This led to the development of casting phenolic resins and laminating polyester resins

Shortly after the end of the war a new resin—the epoxy group—was introduced. Variations of this material for casting and laminating, together with phenolics, today make up approximately 90% of the tooling made of plastics.

The materials making up the other 10% are ethyl cellulose, a thermo-plastic material; Thicol and Polyester. Although Polyester once accounted for more than half of the tooling volume, it has largely been replaced because of the ease in handling and excellent stability of the epoxy group.

The two resins used for the bulk of tooling work today, phenolic and epoxy, are both thermo-setting, that is, once hardened they cannot be resoftened by the use of heat. The phenolic is primarly a casting resin, although some laminating resins are available. This material is usually acid catalyzed and hardened by the use of heat.

Phenolics poured in a previously sealed mold and cured will give a tool which can be used for the forming of metal or other plastic products with practically no machining or alterations. This is generally the least expensive method of arriving at usable tools with many virtues to make it attractive to industry.

The epoxy group were introduced as laminating resins at first to replace the polyester in tooling. The reason for its immediate success was the low volumetric shrinkage, with the laminating technique, enabled almost perfect reproduction of the surface used as the model. These tools were very durable, had high impact strength, and proved to be very stable. Later, by the addition of many types of filler, the epoxy as a casting resin began to play an ever-increasing role in the metal forming field.

Primarily, the use of plastic tooling eliminates the need for machining and lowers direct labor. A further saving is realized from the low investment in tooling needed to make plastic tools. As a result, savings are greatest in tools with much contour, because the use of plastics eliminates the need of costly duplicating equipment.

Some tool uses for which plastics have proved the greatest saving in time and cost are: **1** metal forming tools; **2** gauges and fixtures of all types; **3** plastic forming tools. Because of increasing competition and more rapid model changes, the automotive industry has turned to plastics to speed up their already big production run programs.

There is no limit to the use of plastics for tooling. Little equipment is needed and with a little experience anyone can make good tools. Tool shops capable of making plastic tools of all kinds are established in Canada. Look at your product production — there are places where plastics can save you time and money.

New products & components

New materials and tools designed for you

A NEW EASILY INSTALLED, flexible lining material combining excellent chemical, physical and electrical characteristics, was announced recently by **Kaykor Industries Ltd**.

Called Vyflex L-10, the new thermoplastic lining, based on polyvinyl chloride resins, is suitable for many industrial lining needs. It protects such varied equipment as tanks, fume ducts, tank cars and trucks and the highly complex equipment used for mixing, storing, washing and transporting corrosives.

Vyflex L-10 resists corrosive action from a broad group of industrial chemicals at operating temperatures up to about 160 deg. F.

Because it is inherently elastic, thermal expansion and contraction does not crack it and its good insulating qualities reduce current loss in electrolytic reactions. The inherently smooth, highly polished surface of Vyflex L-10 simplifies cleaning, speeds solution flow and provides superior abrasion resistance.

L-10, which is available in black or white, can be applied quickly in the field or in the shop by competent applicators and when used on steel, wood of concrete, no curing is necessary. (200)

• • •

MARQUARDT AIRCRAFT COMPANY has installed a high-speed, data-processing system that will reduce by as much as 65% the time lag in gaining test results on ram-jet engines.

The $160,000 electronic unit, manufactured by the Systems Division of **Consolidated Engineering Corporation,** will also cut the cost of test instrumentation more than 60% according to Leigh Dunn, chief engineer in charge of Marquardt test facilities.

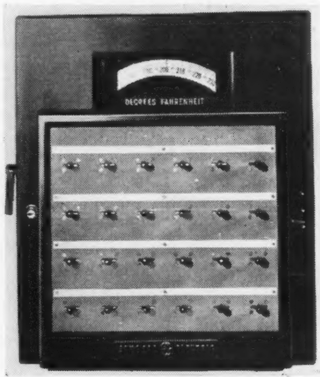
He said that the significant saving in time will radically advance the company's development timetable for long-range, high-speed, high-altitude missiles.

The high-speed Consolidated system will test ram-jet engine pressures, temperatures and fuel flows; transmit that information in electrical form through an amplifier and balancing systems; convert it into numerical values, and record those figures on magnetic tape for direct input to an electronic digital computer or card punch, all in an instant.

In fact, although at normal operating speed 400 readings are converted to digital form in one second, information channels can be sampled at rates up to 1,600 readings a second. The entire system operates with an over-all error of less than 1%. (201)

• • •

A NEW PRECISION INDICATOR, the latest addition to the G-E line of process instruments, is available from **Canadian General Electric Company's** Apparatus Division. The instrument is designed to scan a number of process variables by the use of a manual switching arrangement on the front panel.



CGE's new indicator

Designated Type HJ, the precision indicator may be used with provision for measuring up to 48 different circuits, or in conjunction with a multi-point strip-chart recorder to obtain an intermittent record.

The instrument incorporates a magnetic standard to provide continuous measurement and standardization. The use of this circuit eliminates all maintenance and replacement associated with dry cells, standard cells, and slide wires found in conventional instruments. Operation is possible in ambient temperatures as low as zero deg F or as high as 125 deg F.

Continuous standardization against a permanent magnet reduces manual working associated with conventional instruments of this type. Company process engineers say the use of a permanent magnet also helps assure long-lasting accuracy and sensitivity, and reduced maintenance. The use of plug-in components —range resistor, reference junction oven, and tubes—combined with the use of standard-unmatched tubes helps make the instrument easy to service.

The new precision indicator is available in two basic types, d-c potentiometer or a-c bridge, and it can be provided as a single-point or multiple-point instrument.

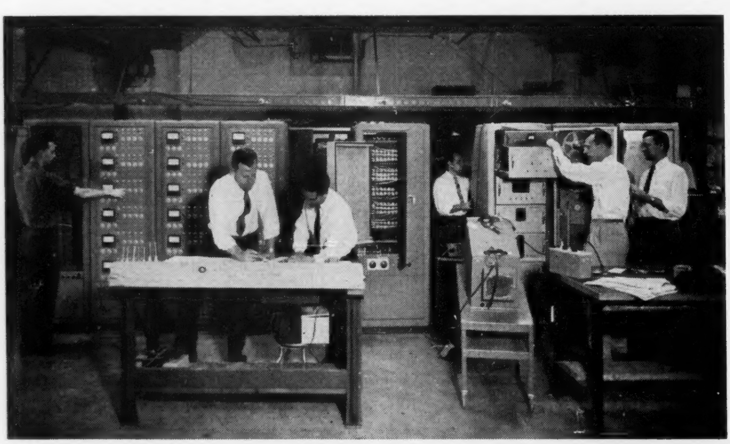
The scale is concentric and rotating and has a length of 32¾ in. Response time for full-scale travel is optionally four or 12 seconds on 60-cycle operation. (202)

• • •

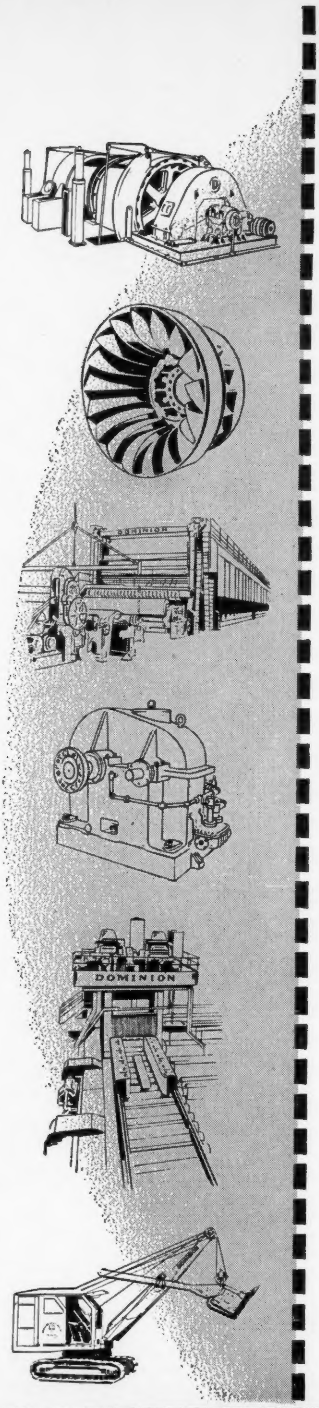
DEVELOPMENT OF A new machine that squeezes teeth onto automotive axle shafts and similar parts 36 times faster than conventional cutting tool processes was described by Harry Pelphrey, chief research engineer for **Michigan Tool Company.** He spoke before a group of engineers and executives attending the 23rd annual meeting of the American Society of Tool Engineers in conjunction with the first ASTE Western Industrial Exposition.

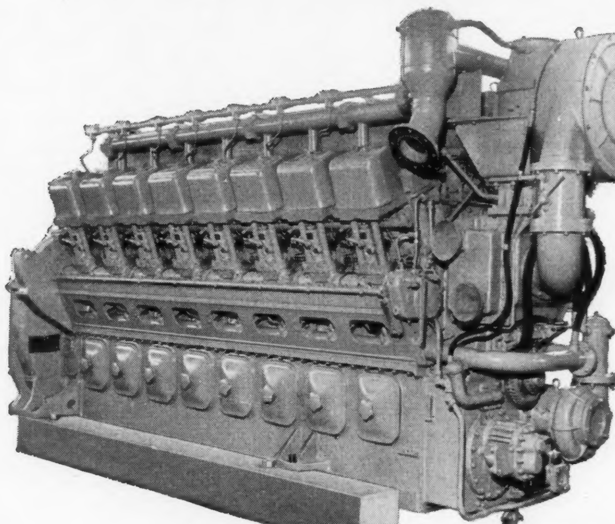
The new cold working process forms the teeth on shafts and similar parts by rolling the part under pressure between teeth-forming racks. Instead of the metal being removed in the form of chips, it is displaced or squeezed into shape.

Tens of thousands of parts can be processed without requiring adjustment. (203)



Testing time 65% less





Isotopes

(Continued from page 37)

was used, the average size of a capsule was about half a curie (a curie is the unit of radioactivity named after the discoverer of radium). Iridium sources are used up to 50 curies and so the exposure time is correspondingly less. What is more, half a curie of radium costs $10,000 whereas 50 curies of iridium cost only $700.

As mentioned earlier iridium gamma rays are among the least penetrating gamma rays known. Because of this they can be stopped by smaller amounts of lead and containers for iridium sources generally weigh less and so are easier to handle. To use our previous example, the safe handling of half a curie of radium requires a 200 lb. container while 50 curies of iridium can be handled in a 60 lb. container.

The contrast in the film is inversely proportional to the radiation energy: so low radiation energy provides radiographs of high contrast.

Canada has been very well-placed for the production of radioactive materials. For more than two years it had the distinction of owning the "hottest" atomic reactor in the world; and while this is no longer true, the Chalk River reactor is still the hottest in which any large quantities of radioisotopes can be produced.

For all practical purposes a nuclear reactor can be thought of as a sort of furnace. There is even insulation around the furnace—in this case a concrete wall many feet thick to prevent harmful radiation from getting out (PICTURE 3). Next comes a reflector made of very pure graphite: this is a device for conserving the neutrons. Neutrons are the atomic particles that make these reactors work; the more neutrons the hotter you can say is the temperature of the atomic furnace. The neutrons are generated from the atomic fuel, which is uranium. In this case the uranium is in the form of long rods, running right through the reactor and cooled by water. The rods run through the heart of the reactor—a tank of heavy water—which serves to control the action of the neutrons and so keep the whole furnace running smoothly.

Now if you put materials into this furnace, they too will be hotted up. Of the neutrons floating around inside the furnace, some will attach themselves to the materials you put in. You put in ordinary metallic cobalt and it picks up some neutrons to come out as "hot" radioactive cobalt 60. Iridium metal comes out as iridium 192, common salt as sodium 24, thallium as thallium 204. These materials have changed into radioactive forms, and they continue to give off energy in the form of beta or gamma radiation. To carry the furnace analogy one step further, the fuel (uranium) burns in an atomic furnace to leave a radioactive ash known as a fission product. From this ash it is possible to get materials for industrial uses. Strontium 90, caesium 137, ruthenium 106, cerium 144 are all radioactive istotopes separated from fission products in this way.

In the field of instrumentation there are two basic types of gauge which Isotope Products call the betameter and the gammagage, after the two types of radiation, beta and gamma rays.

The betameter family is mainly for the measurement and control of thin sheet materials on the mill, in the paper industry or in making plastic sheet, rubber sheet and metal foil. In addition, it is used for measuring many other sheet products, from sandpaper to adhesive tape, from glass fibre insulation to linoleum.

The gammagage family

The gammagage family, on the other hand, handles much heavier material—up to several inches of steel or several feet of liquid in a tank. One of its primary uses is for measuring fluid density. It is much used in the chemical industries, in mining and refining and in the oil, petro-chemical and food industries.

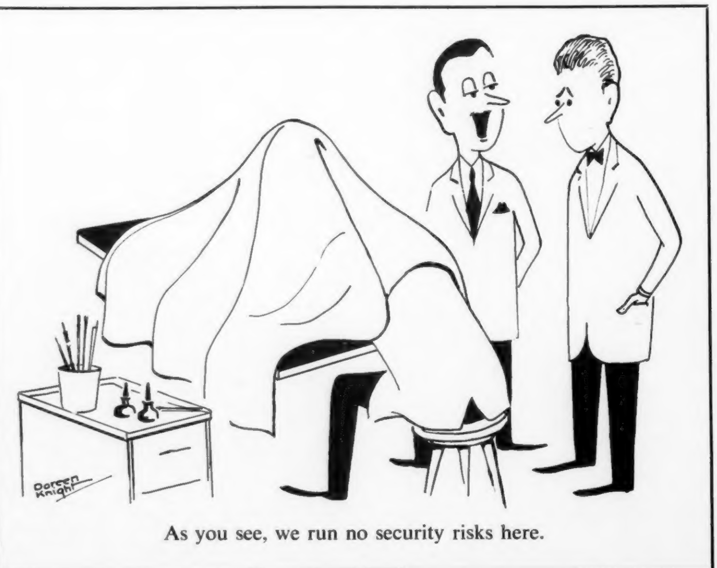
The betameter and the gammagage have similar components. To use them a source of radiation is mounted on one side of the unit under test and a detector of radiation on the other (PICTURE 4). On a paper machine, for example, a heavy yoke would hold the source (emitting beta rays in this case) and the detector a few inches apart, with the paper running between them. In a density installation of the gammagage, the source of gamma rays (in a heavy lead block) could be mounted on one side of a pipeline and the detector mounted opposite. The detector measures the amount of radiation stopped by the intervening material, by the paper sheet or by the fluid in the pipe. This measurement is transformed, by means of a DC amplification circuit, into a continuous chart record or into a continuous process control.

The basic problem in the design of all radiation gauges is how to ensure stability. Several factors make for instability in these gauges—fluctuation in the radiation from the source, variation in power supply, source decay, amplifier instability, temperature and pressure effect, to mention the most significant. The history of betameter development in particular, has been one of steady elimination of these factors until now an accuracy of 1/10 of 1 per cent is possible.

Luckily many of the sources of instability can be removed by a single design feature—balanced operation. This means that the instrument contains (in addition to the measuring source and chamber) a second source and chamber whose current is opposed to the measuring current. In the betameter, an identical source is used, while in the gammagage the balancing source is often a beta source of about the same half-life. The balancing source has a controllable iris mechanism, which can be set at will.

Instead of the amplifier dealing with the full current coming from the mea-

(Continued on page 71)



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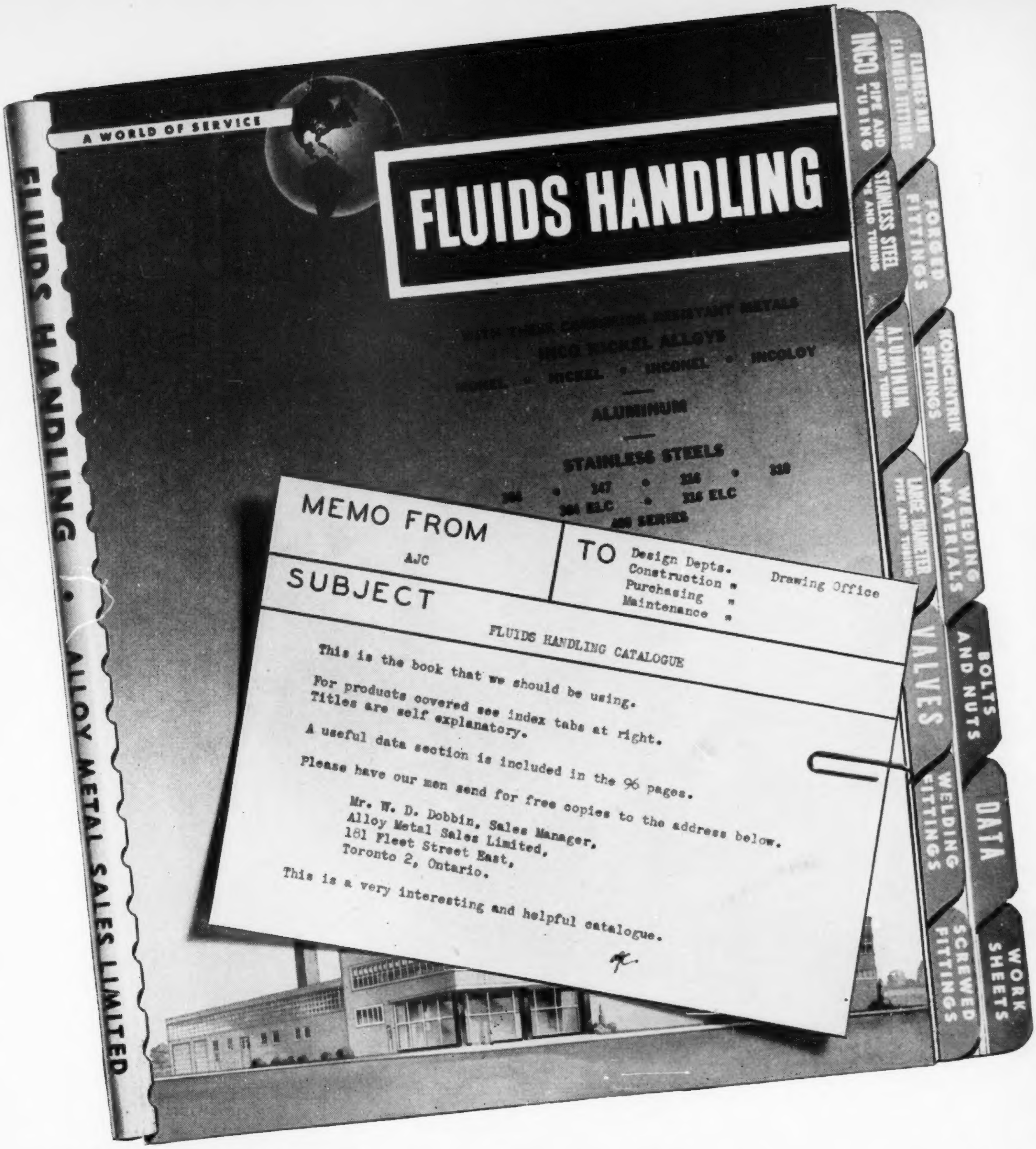

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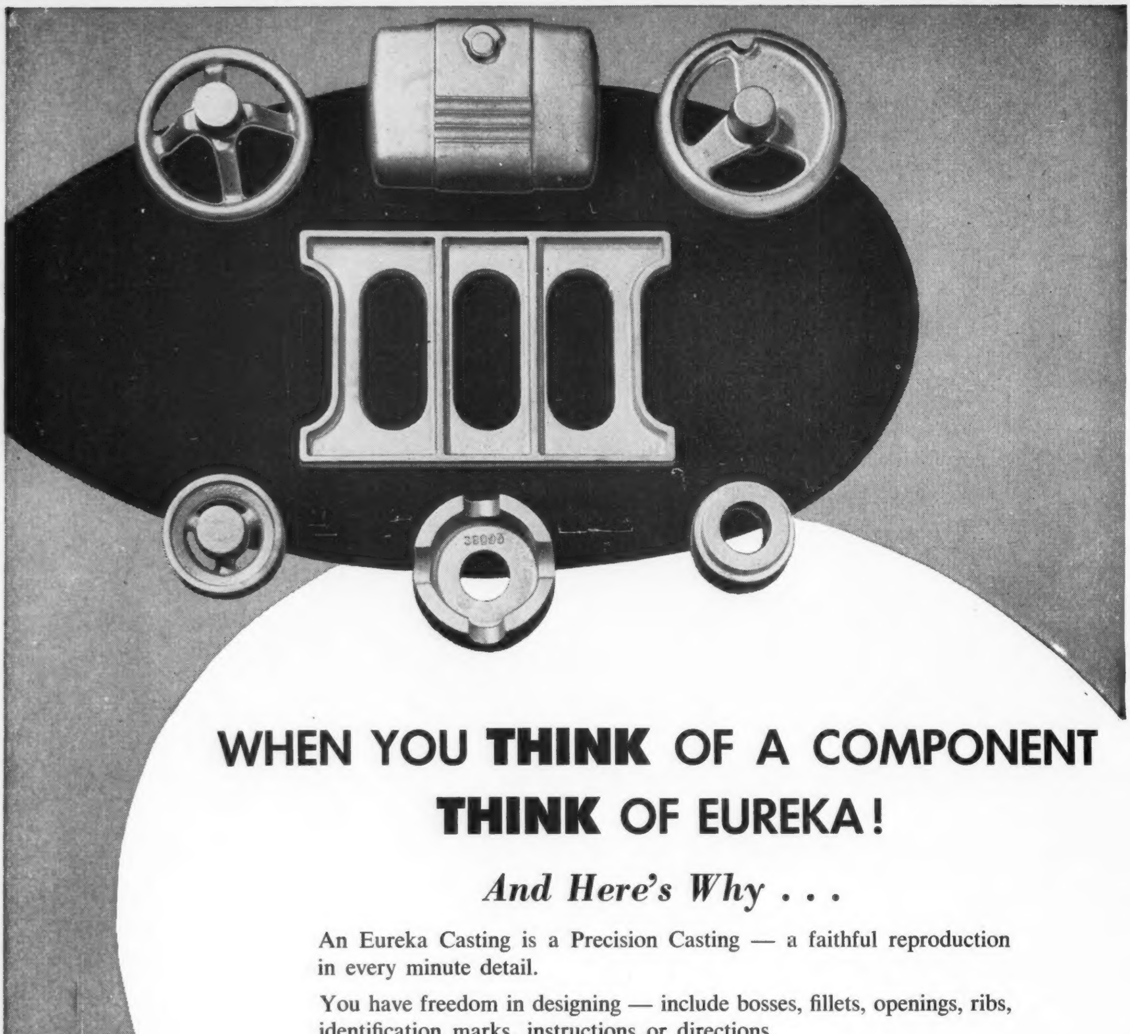
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New products and literature

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The Rolling Hockey Puck Has Come

With 3 inserts and bearings you can take away the ice, and still enjoy ice hockey

YOUR BRAINS DON'T WORK 'til you're 60," remarked grey-haired Andrew Watson after patenting a new iceless "ice" hockey puck. "But now, at 65, I've reached the stage where I don't know what I'm coming up with next."

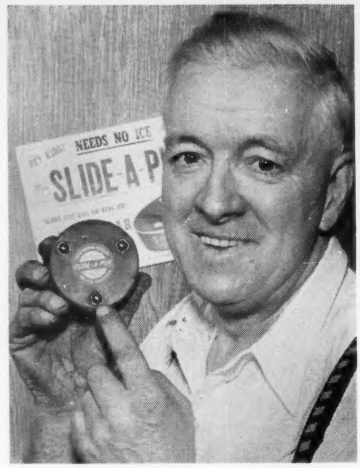
However, there is evidence that Andrew Watson, exiled Scot who came to Canada in 1923, put his own brains to work earlier than he admits. In 1940, for instance, he is said to have invented the land mine which went into immediate and dramatic action in Egypt—but he was never given credit for it; and before that, he designed and patented a super-economy furnace which was too expensive to make in quantity but saved 50% of fuel costs in use.

This time, he believes he has a winner. The new puck (trade name: Slide-A-Puck) is standard in every way except that three mild steel cup inserts are driven through the rubber to carry three projecting ball bearings on each surface. On these bearings, inventor Watson claims that the puck will travel over hardwood as quickly as an ice puck will slither across a rink.

He made a prototype, then tested it by primitive but thorough methods: "I bashed it against a wall with a polo stick for an hour. Sparks flew everywhere; but I couldn't damage the puck." Satisfied that the puck had a future, Andrew Watson then pressed out 1,000 and started giving them away. TV star Arthur Godfrey has one, so have the Army, Navy and Airforce chiefs. Merchandising arrangements are now being made in Canada and the U. S. and the Watson metal working shop is drawing breath to produce 1,000 a week (retail price $1.50) when the demand begins.

Construction of the slide-a-puck is extremely simple. The inserts, made fractionally oversize, are squeezed into prebored holes. Mild steel ⅜ in. balls are dropped into the cups which are then punched four times to distort their circular rims roughly square to hold the balls. For safety, he shaves off the sharp edges of the standard puck.

The idea came as Andrew Watson watched children playing street hockey with a bundle of rags tied into a ball. He believes it will replace the felt pad used for floor hockey. ★



Inventor Andrew Watson

Titanium

(Continued from page 47)

molybdenum additions and sufficient aluminum to hold a high strength up to 1,000 deg. F. It is used by jet engineers for compressor wheels, particularly for the later stages where high temperature builds up as the air is compressed.

Rem-Cru A-110 AT contains 5% aluminum and 2½% tin and is an alloy which welds well; the aluminum content gives it good high temperature strength. It is the first commercial titanium alloy to use appreciable amounts of tin. This increases the hot workability and broadens the range at which A-110 can be forged. It is an alloy likely to be important to the aircraft design engineer.

Ti-150A is used for plate, bars and forgings and contains iron and chromium additions.

Ti-140A is a medium strength alloy for sheet and strip, bars and forgings, which is conspicuous for high temperature stability and excellent impact resistance. Alloying elements are iron, chromium and molybdenum.

The 70,000 psi yield strength titanium is not used for high temperatures because of its poor behavior under strong heat.

As stated earlier, a strong feature of the titanium alloys is their high strength-to-weight ratio (or specific strength as it is called) at room and high temperatures. This is shown (PICTURE 3) in contrast with 403 stainless steel and 14S aluminum.

Titanium and its alloys may be hammer or press forged on conventional equipment used for steel. The forging temperatures for titanium may vary from 1,450 deg. F to 1,850 deg F depending on the alloy composition and section size. From 30% to 50% more power is required for forging a given titanium section than a steel one, because of the lower temperature involved.

The machining behavior of titanium and its alloys is in general similar to that of the 400 series of stainless steel, although some alloys are classed in machining performance with the high temperature superalloys. Specific advice on machining the various grades of titanium and its alloys can be had from the producers of the metal.

Used mostly for aircraft

Most of the present uses for titanium and its alloys are in jet engines or jet aircraft frames. The present high cost of metal prevents its use for many promising civilian and naval uses. But the density of titanium, (between aluminum and steel) combined with its high strength, has made it a necessity in aircraft of the future, where higher temperatures have made aluminum undesirable and there is a weight penalty when steel is used. Typical uses in this field are: jet engine compressor wheels, blades and stator rings.

It is also suitable for fire walls, shrouds and engine nacelles. In fact, in the Canadian CL-28 version of the Bristol Britannia, the nacelles back to the wing front spar and a short portion of the leading edge as well as the firewalls (with monel rivets) will be of titanium. A big weight saving over stainless steel is expected because of it.

The commercially pure AMS 4900 will be used for parts to be stretch formed. All others (flat or with single curvature) will be in the stronger AMS 4901.

Its use is justified in the chemical industry even at its present high cost. Titanium has excellent corrosion resistance to sodium and calcium hypochlorite and this has led to its use in the manufacture of commercial bleach. It has excellent corrosion resistance to chlorine dioxide which the Canadian paper pulp industry uses. It also shows tough resistance to sulphuric acid under oxidizing conditions. For this reason it is used for anodizing racks, electro-plating racks and in chemical ore refining.

Its use is also proposed for military tanks, because its high strength-to-weight ratio means that less hp, and therefore fuel, will be needed.

This will all help airborne operations. Then the fact that titanium is immune to sea-water means that it is a very suitable material for use by the army for amphibians and by the Navy for snorkel and condenser tubes.

Many articles made from titanium were on display in New York last year; these included camera shutter leaves, wire for artificial limbs and a racehorse shoe. There will be many more soon. ★

File

New booklets and books written for you

DETAILS ARE GIVEN, in a **Canadian General Electric publication,** of the uses of Deltabeston power and control cables, electrical appliance wires, cords, fixture wires and switchboard wires and cables.

Deltabeston wire and cable is designed for use when there are severe operating conditions of extreme heat, high humidity, grease, oil or corrosive vapors.

The basic insulating material is asbestos fibres applied to the conductor by a process which gives a uniform, compact, seamless coating of fibres of controlled density.

• • •

IN A BROCHURE on high speed pen recorders **Kelvin Hughes** explains that the use of direct-writing instruments for recording variable electrical quantities has until recently been confined to cases in which the rate of change was comparatively small.

When frequency components greater than a few cycles per second were met, direct recording was no longer possible and it was necessary to use photographic recordings with Duddell or cathode-ray oscillographs.

The disadvantages of photographic recording are well-known. One of these is that a photographic record cannot be inspected until it has been processed in a darkroom and so the operator does not know immediately whether it gives him the information he wants.

The development by Kelvin Hughes of a moving-coil element that can be driven by a simple valve amplifier and having sufficient restoring torque to enable it to deflect a stylus across its paper record in as little as two and a half milliseconds, now enables records of high speed phenomena to be presented for immediate inspection in a dry and permanent form.

Moreover this stiffness of the suspension results in an instrument that is robust and insensitive to external vibration so that it can be used in aircraft or vehicles.

In this range of high speed recorders, the single channel and four channel instruments employ Teledeltos dry electrolytic recording paper, which gives an instantaneous and permanent record, consisting of a fine black trace on a light grey ground and needs no servicing or attention whatever. Only the seven pen magnet unit uses ink and plain paper, because it was designed primarily for use in hospitals and biological laboratories where there is more opportunity for cleaning pens and feed tubes.

• • •

SUPERSTON 40 BRONZE is the subject of a **J. Stone and Co.** leaflet. It is a copper-base alloy of an entirely new type and the result of years of research devoted to the development of an alloy with high mechanical and fatigue strength, with good ductility and corrosion resistance, even in sea water.

It is suitable for large and intricate castings and is not so difficult from the foundry point of view as aluminum bronzes of similar tensile strength. Even in large sizes, a fine grain size is possible, and this gives a sounder metal and less scatter in the mechanical properties in a single casting.

Castings can be made pressure-tight up to 1,200 psi. The alloy can be machined by the use of suitable tools, takes a fine finish and is weldable.

Typical uses are for turbine runners, pump cases, valve bodies, pressure-tight castings, spindles and so forth. To overcome the porosity in metals various materials, organic, inorganic and mixtures of the two, have been used as sealants without complete success.

• • •

THE DEVELOPMENT OF METASEAL 19V5, results in an improvement over other solventless impregnation processes claims the **American Metaseal Manufacturing Corp.** in a new brochure.

It does not need refrigeration, agitation or aeration and so the viscosity is maintained at a value suitable for all castings.

It is also claimed that because of the excellent wetting properties of 19V5 there is positive pore penetration and leak prevention. Other advantages are its excellent corrosion resistance and dielectric properties.

• • •

THE PURPOSE OF a booklet from the **Eaton Manufacturing Company** is to give information on the principles and uses of the Dynamatic eddy-current adjustable speed drives. Basic principles are first discussed and it is shown how torque is generated by eddy-current devices.

Graphs of relative torque versus per cent slip and versus rpm output are then given, together with notes on heat characteristics, cooling, efficiency, control and operating characteristics.

Typical equipment mentioned includes the adjusto-spede drive, liquid-cooled and air-cooled couplings, liquid-cooled and air-cooled brakes and eddy-current dynamometers of three types: absorption, motoring and universal.

• • •

IN A NEW folder by **Leland-Newman Co.** details are given of a range of totally enclosed, fan-cooled, squirrel cage motors with outputs from half to 25 hp. They are available in three types: foot mounting, D Type and C Type flange mounting, with or without feet.

The motors comply fully with the new NEMA specifications for mounting dimensions. Tables are given, for foot-mounted and base-mounted motors, giving hp ratings, fixing dimensions, shaft, keyway and key details for various NEMA frame references.

• • •

MELMAC 3135, according to a leaflet of the **American Cyanamid Co.,** is a glass fibre reinforced melamine formaldehyde molding material with good compression and transfer molding characteristics.

It has been designed to have high impact strength, good electrical properties and flame resistance.

In the leaflet, details are given of its distinctive properties such as impact strength, heat resistance and so on.

Applications next discussed are mainly in the electrical field and include heavy duty switch gear, terminal strips, sockets and coil forms.

Notes are given under headings such as storage and handling, preforming and preheating, molds and molding, finishing. A tabular list of technical data winds up the leaflet.

Book Department

What Every Engineer Should Know About Rubber

A NEW TEXT BOOK published by the British Rubber Development Board, has been written by **W. J. S. Naunton,** consultant on rubber and plastics to the Admiralty.

Two of its six chapters are of special interest to design engineers: Chapter two gives a practical classification of rubber types. Three groups are listed as **1** Vibration insulation and isolation (shock absorbers, anti vibration units); **2** Distortional systems (flexible couplings, seals); **3** Protective systems for use against abrasion, corrosion and electricity.

In chapter five, the engineering uses of rubber are dealt with at some length. The information covers anti-vibration systems, rubber bushes, sound insulation, belts, hose, cables, seals and hydraulics.

The book is well printed, easy to read and well indexed. It has one fault: the pictures are not captioned and should have been. But "What every engineer should know about rubber" is worth having on your shelves.

Silicones Family

(Continued from page 31)

mineral has been superseded by the ultra fine colloidal products developed by Dr. Edward G. Acheson. The process used subjects anthracite coke and other carbonaceous materials to a strong current in an electric furnace. As the temperature is increased to 5,000 deg. F or more, the impurities are volatilized, leaving a pure synthetic graphite. Dr. Acheson also invented ways by which this graphite could be dispersed in various liquids in a colloidal state. Average particle size was estimated at 75 millimicrons, allowing them to be permanently and evenly suspended in water, organic solvents, or oil.

Today these products are widely sold under the name of "dag" dispersions. They have the power of laying down a tough, firmly adhering porous film of graphite over metal. This film will hold any other lubricant to the wearing surface —which is of particular value in the running-in of new machinery. The sliding surfaces in such cases are never smooth enough to allow even wetting by oil. But a graphoid film adheres to the metal, doing a lubricating job of itself, while providing a surface over which liquid lubricants can flow.

In slow moving, very high temperature cases such as the moving parts of oven conveyors, graphite is widely used. In combinations with oils, it gives lubrication after the liquids have been destroyed. It provides high temperature lubrication of a type which cannot be equaled any other way. In fact there is not a single high-temperature liquid lubricant whose properties for special uses cannot be improved by adding colloidal graphite.

Lubrication is now a very advanced study. Of all the scientists contributing to our mechanical advances, the work of the chemist has been most hidden. But it has for long been of top importance. It is going to stay that way in the future. ★

Uses for Isotopes

(Continued from page 62)

suring head, it has only to deal with very small currents caused by the deviation from standard, the amount "off-weight" of a paper sheet, for instance. This reduction of the current brings the DC amplifier into a much more stable operating range. At the same time, since it aids amplifier operation, the balanced system compensates for source decay. The measuring source and the balancing source are decaying at the same rate and the difference current remains constant.

In a betameter measuring very fine paper, the weight of air in the measuring head, may be almost as much as the weight of the paper. This air will change in weight as the temperature of the surroundings and the barometric pressure alter. However, by making the air gap between the balancing source and the head the same as that between the measuring source and the head, this source of error is eliminated. Of course, in a gammagage measuring thick steel or fluid density, these finer points are not important, but balanced operation still stabilizes the amplifier even in these cases.

An ingenious way of using balanced operation is in the measurement and control of coatings. Here the balancing source and detectors are identical in design and function with the measuring source and detector. One head is mounted opposite the uncoated stock, the other opposite the coated stock, and the two heads are, as before, coupled in opposition. The resulting cunrrent gives a stable measurement of the coating thickness and so can easily be used for control.

Two vitally important points about radiation instruments are that their operation is continuous and non-contacting. There is no sampling step involved and process control can be made instantaneous. With a noncontacting instrument anything can be measured—no sheet is too slippery or too soft, no liquid is too sticky, too impure or too corrosive. The gammagage, for example, will measure anything from water solutions to heavy tars, foodstuffs to concentrated acids. paint to ore suspensions. Its use is not even confined to liquids: the bulk density of fluidized solids like grain, powdered coal or wood chips can be measured.

A number of exposure cameras for various field uses have been developed, most of which are designed to be carried and operated in perfect safety by one man. For example, a 45-lb. gamma camera, with a rotating stepped door, is used for inspecting castings. For inspecting welds on oil storage tanks, two cameras have been designed and built. One is a light-weight (15-lb.) unit which can be suspended from the tank wall by a magnet and used to take spot shots instead of trepan sections. The other is used for more detailed radiographic inspection of tank welds up to 30 ft. above the ground.

Pipeline weld inspection is another big field for the use of radioactive isotopes. An external camera for shooting such welds from outside the pipe has been used on every major Canadian oil and gas line built in the last three years. Protoype models are available also of a camera for shooting pipeline welds from inside the pipe, a camera for shop-made pipe welds and for penstock welds. ★

Piston Vibrations

(Continued from page 57)

(PICTURE 7) with four small masses representing the WR^2 effect of the engine parts acting on each of the crankpins and the larger masses representing the WR^2 of the flywheel and the generator rotor. Relative amplitudes for the 1st, 2nd and 3rd frequencies only are shown. Higher frequencies are not usually of practical importance in such a system.

Unfortunately, many engines are built in such a way that it is next to impossible to arrange a torsiograph drive from the free end of the crankshaft. In such cases, it is worth the extra trouble to improvise extension shafts, special cover plates, oil slingers and so on to get a free-end drive. Any extension shaft or pulley which is coupled to the crankshaft should be as robust and stiff as possible: the connection must be perfectly solid with no suspicion of slip or backlash. If this is not done there will in effect be an extension of the normal elastic curve and the vibration as recorded will not be quite true. Furthermore, the belt tension required to prevent slip is in the range of 60 lb. and this could impose quite a bending stress on a flimsy extension shaft.

Even after taking every care it is usually impossible to tune all criticals outside the running range; so the question naturally arises. How can we assess the seriousness of criticals and by what standard can we decide whether a critical is acceptable as it is or whether efforts should be made to reduce or move it?

The usual way to judge the importance of a critical is to calculate the maximum shafting stress which it will set up in the system and if the stress is within the limits set by various societies, such as Lloyd's Register of Shipping, who have taken the initiative in publishing recommended limits, the critical is said to be allowable for either continuous running or for transient running. The torsional fatigue limit is that property of the material which measures the magnitude of alternating stress which can be withstood indefinitely. For 1040 steel forgings, it is approximately 20,000 psi in shear. Allowing a safety factor of 5, the allowable additional stress due to torsional vibration would be about 4,000 psi and this is considered a safe working value for continuous operation on a critical. ★

Advertising index — May

Editorial

How Canadian Should Our Industry Grow?

AN OFF THE RECORD remark by an old and widely known Canadian engineer is worth repeating: "My biggest worry about Canada," he said, "is the Americanization of our industry."

One day before, the Canadian Consul General in New York quoted our trading deficit with the U. S. of $800 millions and warned that "there are no grounds for being complacent about the situation."

A little ahead of both of them, H. H. Rogge, president of Canadian Westinghouse, announced to the Guelph Board of Trade that our industry is still on trial. "Doubts of its value are not often expressed openly," he said. "But they are shown clearly in our economic and political thought." Mr. Rogge believes we are too little concerned about the great industrial future that could be Canada's; or could, on the other hand, pass Canada by.

These are the views of men who, from their high places, see the broad complex panorama of Canadian industry; and these men are worried. Why? Be sure there are good reasons.

It is true that the Canadian standard of living is very high; that the Canadian dollar is very hard; and that the Canadian citizen is very happy. But the standard of living comes partly from the investment of foreign money and the sale of raw materials that we may, when processed, buy back; and the Canadian dollar is very hard because foreign investments still come which may later slow down as dividend payments speed up; and the citizen's happiness may mean he is not quite aware of his dependence on outside interests.

It is not only "Americanization" that confronts us; it is also "Britishization," and "Germanization." In one clumsy word it is "foreignization" that Canada must face — and face now.

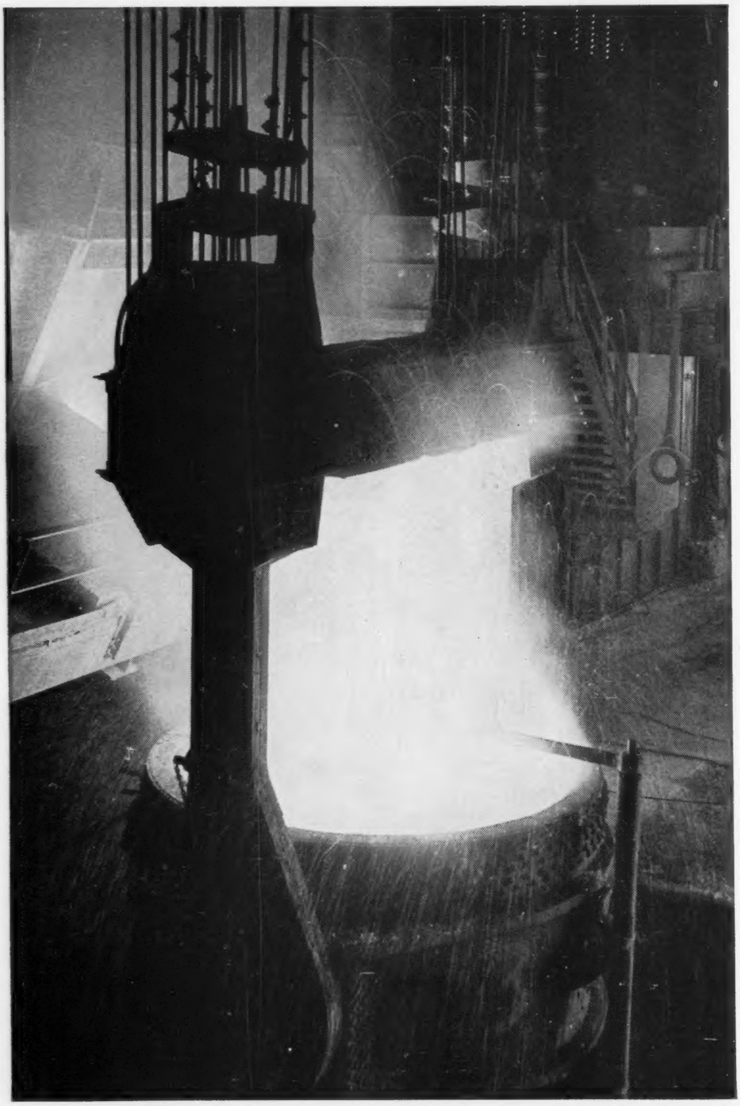
And all this is very close to the engineer. Economists are famed for their ability to debate but none seems to doubt the value of our creative engineers. Whatever might be said for and against trade and tariff manipulations, all educated viewpoints seem agreed that we need good engineers. There is little argument here; yet, there is little action too.

For "foreignization" comes from the big industrial nations with huge development resources behind them; what hope has Canada of holding her place among them unless she too fosters (and pays for) bigger development projects? Surely she has very little.

"I have tremendous faith in our engineers," Mr. Rogge has told **Design Engineering.** "Someday we shall look back at the 1950s and speak of how they helped us gain a competitive position in the world."

This is good news. But it has to mean that management and government plan to back them all the way.

We make our own fine alloy steel—and make it nickel-rich—to make TIMKEN bearings tougher



NICKEL makes steel tougher. So, our steel-making specialists don't skimp on nickel in the fine alloy steel we make for Timken tapered roller bearings. They use exactly the right amount of nickel to give these bearings the toughness they need to withstand shock and last longer. Exacting quantities of chromium or molybdenum or both guarantee uniform hardness. By using the steel industry's first direct-reading spectrometer, we exercise hairline control of each element at the precise instant of tapping the furnace.

Rolling, annealing, and cooling are done with the same meticulous care. And every race and roller that goes into a Timken bearing is precision case-carburized to give it a hard, wear-resistant surface over a tough, shock-resistant core.

We've been specializing in the production of fine alloy steel for almost forty years. We make our own steel, because it's the only way we can make sure the quality of our bearing steel is just the way we want it. Steel is the heart of the bearing. That's why we insist on controlling bearing quality *every* step of the way—from melt shop to final bearing inspection. And that's why we don't skimp on the use of nickel.

To be absolutely sure of the highest performance standards in the equipment you build or buy, always specify Timken tapered roller bearings. They are made from seamless tubing or forgings by the most modern processes, under strict control. Only Timken bearings roll so true, have such quality thru-and-thru. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

CANADIAN PLANT: St. Thomas, Ontario.

U. S. PLANTS: Bucyrus, Canton, Columbus, Mt. Vernon, New Philadelphia, Wooster, and Zanesville, Ohio; Colorado Springs, Colorado.

SEE THE EXHIBIT of Timken bearings and Timken rock bits at the Canadian International Trade Fair, booth 4812-4813. Toronto Exhibition Park, May 30 through June 10. All of these Timken Company products are made in Canada by Canadians for Canadian industry.

TIMKEN Made in CANADA
TAPERED ROLLER BEARINGS
FOR CANADIAN INDUSTRY

Only **TIMKEN** bearings roll so true,
have such quality thru-and-thru